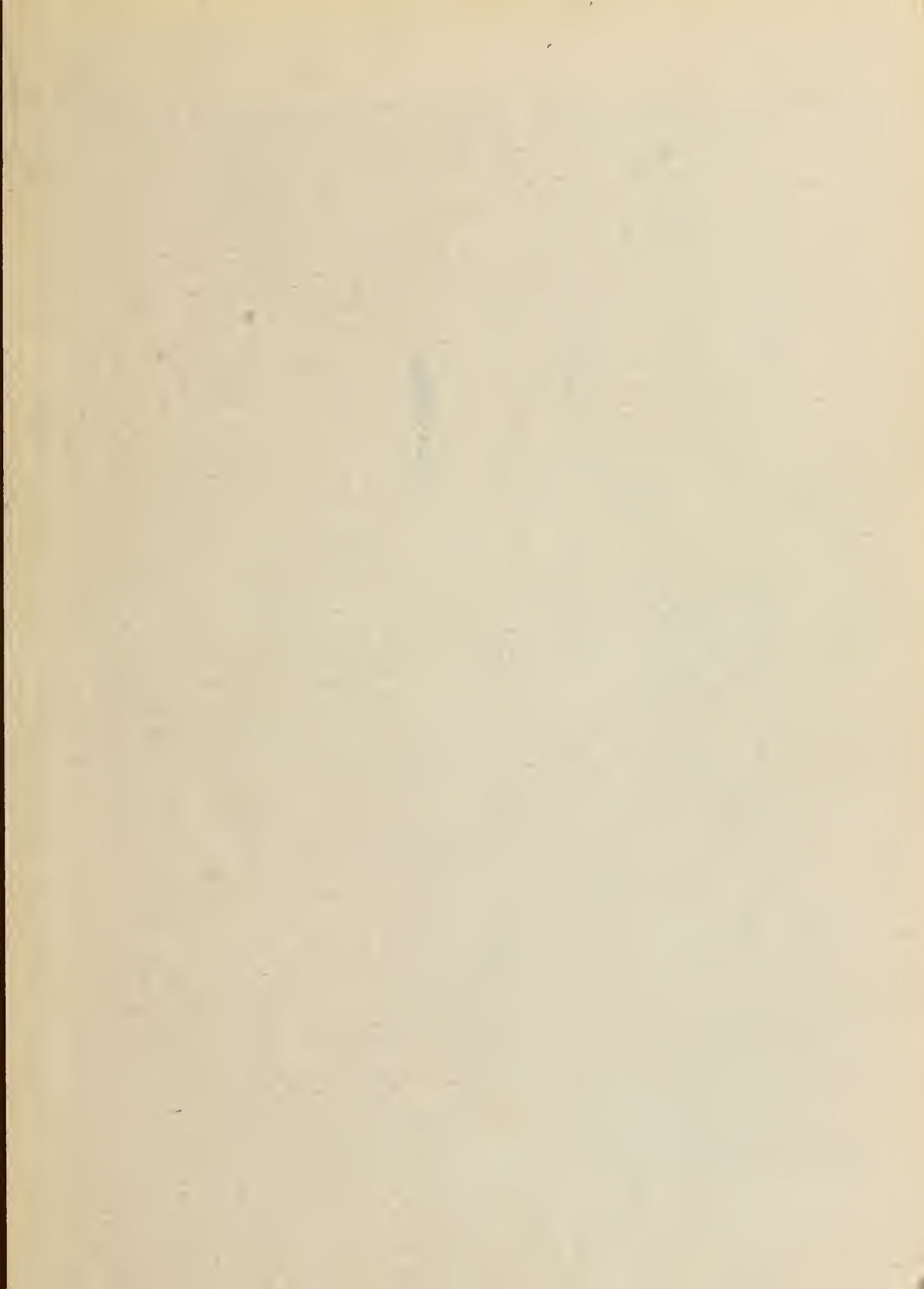




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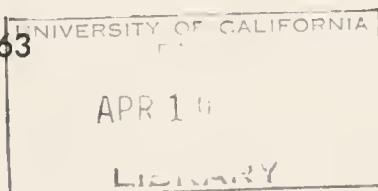
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Department of Water Resources

BULLETIN No. 97

CALAVERAS AREA
INVESTIGATION

Reconnaissance Report

OCTOBER 1963

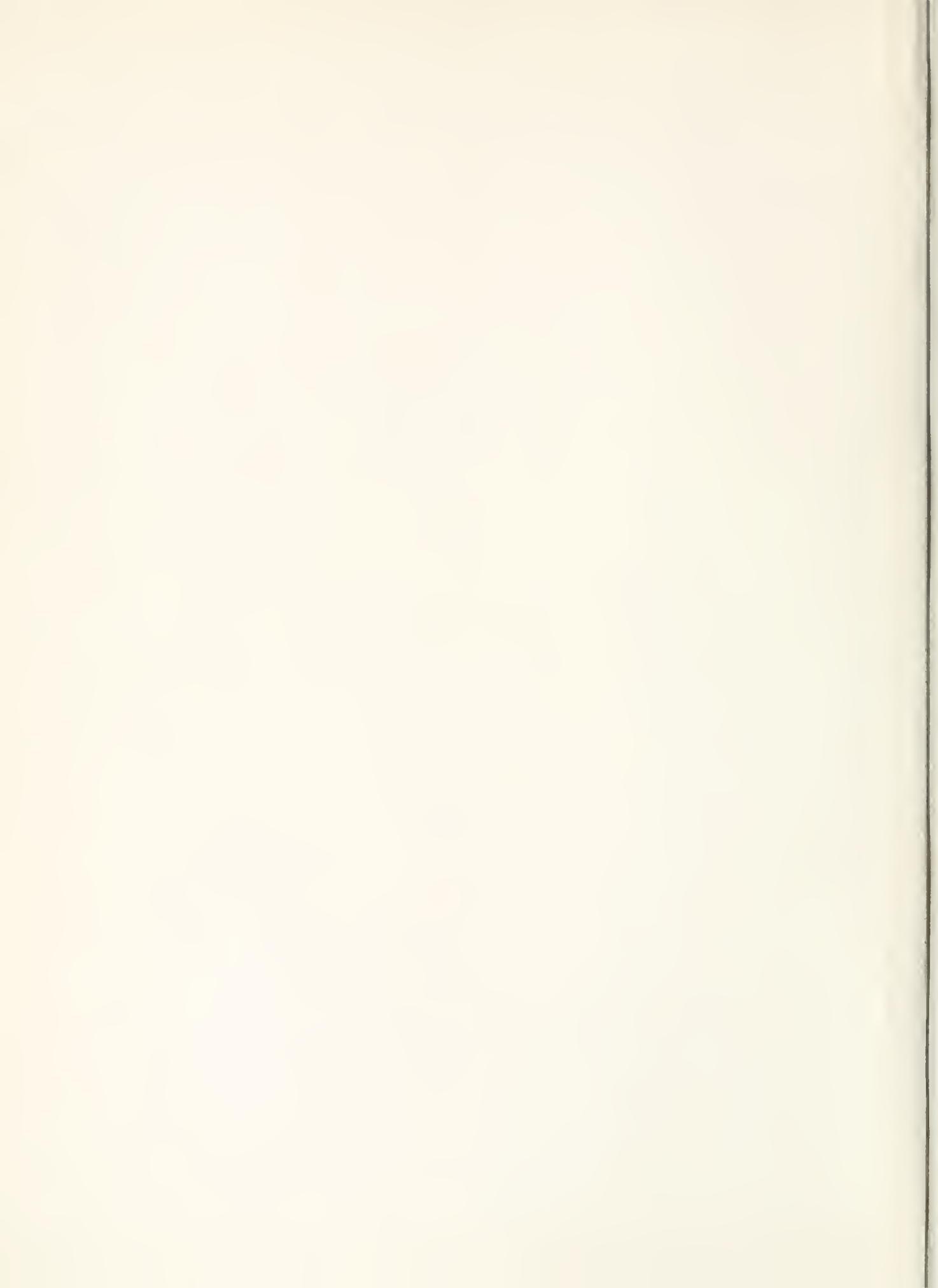


HUGO FISHER
Administrator

The Resources Agency of California

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources





State of California
THE RESOURCES AGENCY OF CALIFORNIA
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ACKNOWLEDGEMENT

Valuable assistance and data used in the investigation were contributed by agencies of the federal government, the State of California, cities, counties, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

Bureau of Reclamation, United States
Department of the Interior

California State Water Rights Board

State of California, Department of Fish
and Game

East Bay Municipal Utility District

Calaveras County Water District

Calaveras Public Utility District

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THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

1120 N STREET, SACRAMENTO

July 10, 1963

Honorable Edmund G. Brown, Governor
and Members of the Legislature
of the State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 97 of the Department of Water Resources, entitled "Calaveras Area Investigation: Reconnaissance Report." This investigation was given direction in 1957 by Senate Concurrent Resolution No. 109. This resolution directed that the area of investigation include the foothill and mountainous areas within the watersheds of the Mokelumne, Stanislaus, and Calaveras Rivers and the valley lands adjacent thereto, including the City of Stockton.

During the course of the Calaveras Area Investigation, the federal government has started construction of New Hogan Dam and has completed planning of New Melones Dam on the Mokelumne River, Auburn Dam on the North Fork American River, and Folsom South Canal. These projects are logical sources of future supplemental water supplies to serve the valley and lower foothill portions of the Calaveras Area.

Bulletin No. 97 presents reconnaissance plans for the development of water resources in the Calaveras area which consider the full utilization of the foregoing federal projects. The initial future project proposed for serving the upper Calaveras area would divert water from the North Fork of the Stanislaus River in order to provide a flexible system from which future releases of water into upper Calaveras County could be economically provided. Several possible future reservoirs for serving local service areas are also considered. These sites are considered to have the most promise for more detailed study as future water needs mature.

Sincerely yours,

A handwritten signature in cursive script, reading "William E. Warner".

Director

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THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

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CHAPTER I. INTRODUCTION

The rapid development of the State of California, with its attendant increased use of water, has intensified the water problems of many areas of the State. The Calaveras area, which lies between the Stanislaus and Mokelumne Rivers, is such an area. Within this area every type of use and need associated with water development can be found.

The area covered by this investigation included all of Calaveras County and adjoining portions of Stanislaus and San Joaquin Counties that are dependent upon the Stanislaus, Calaveras, and Mokelumne Rivers for water supplies. The area of investigation is shown on Plate 1, "Location of Calaveras Area."

The runoff of the Mokelumne, Stanislaus, and Calaveras River systems is utilized to meet most of the current demands of Calaveras County. It is anticipated that most of the future increase in water demands within this county will be met by further development of the waters of these rivers.

In the San Joaquin and Stanislaus County portions of the Calaveras area current supplies are obtained from these rivers and from ground water. Because the ground water table is dropping, most of the future increase in water

demands must be obtained by importing water from outside sources.

The Calaveras County Water District, which is countywide, was formed in 1946 to provide a local planning agency for water development. Since being formed, the district has worked with Amador County and the East Bay Municipal Utility District to determine the disposition of the waters of the Mokelumne River and has proceeded with planning for the development of the waters of the Stanislaus, Calaveras, and Mokelumne River systems for its use.

Authorization of Investigation

Specific guidelines for this investigation were provided in 1957 by Senate Concurrent Resolution No. 109, which provided in part:

"...to expedite the current investigation of the Mokelumne, Stanislaus, and Calaveras River watersheds, and the formulation of plans for the single or multipurpose projects for the development thereof under The California Water Plan including consideration of the proposed Folsom South Canal, for the major purpose of developing water to serve the foothill and mountainous areas within the said watersheds and valley lands adjacent thereto, including the City of Stockton."

Objective and Scope of Investigation

The objective of the Calaveras Area Investigation was to investigate various possible plans for the development of water supplies and to formulate plans for those projects which would be of immediate benefit within the purview of the legislative intent as set forth in the various budget acts cited above. Since the inception of the Calaveras Investigation, the federal government has started the construction of the New Hogan Dam and has recommended the construction of New Melones Dam and Folsom South Canal. Although these projects had been considered prior to the authorization of this report, the effect of these developments as currently formulated was uncertain as to the needs of the area. Concurrent with the formulation of these projects, the objectives of the Calaveras Investigation were modified to shift the emphasis away from the San Joaquin Valley floor portion of the area, since this region would best be served by the federal projects. To attain this objective it was necessary to make inventories of the water requirements and resources of the Calaveras area. Using the data developed in these inventories, general plans were formulated for an initial project which would be economically justifiable and which would provide a flexible system from which further development of local, multi-purpose projects could be extended as the need matures.

Data developed for previous investigations, including the Statewide Water Resources Investigations, were reviewed and utilized.

Studies of the projects considered for immediate development included determinations of engineering feasibility and economic justification. Studies of projects intended for future construction were limited to determinations of engineering feasibility.

Conduct of Investigation

Field work and office studies for the investigation began in October 1956 and continued into the fall of 1961. Hydrologic studies, including the collection and compilation of precipitation and streamflow data, were made to estimate the surface water supply available in the Calaveras area. Portions of the data on ground water conditions in the valley floor portion of the area of investigation were taken from Bulletin No. 11, "San Joaquin County Investigation." These data were supplemented by field measurements during the investigation.

Seventeen damsites were studied. Geologic mapping and exploration operations were conducted at the major sites to determine foundation conditions. Topographic surveys, using photogrammetric methods, were made of 14 of these sites. Foundation core drilling operations were conducted

at eight sites, and auger holes were drilled at nine sites. Borrow areas containing possible construction materials were located and mapped, and samples were taken for laboratory testing. Geologic mapping of two powerplant sites and some 50 miles of conduit route was accomplished. A regional geologic map of Calaveras County (Plate 5) was prepared from field surveys.

Previous studies of land use on the valley floor of the area of investigation were reviewed. A resurvey of the entire area was made to determine present land uses. New land classification studies were made throughout the Calaveras area. These studies provided the basis for estimates of present and future water requirements. During the course of the investigation, however, it became apparent that future supplemental water supplies for the San Joaquin Valley portion of the area could not be developed from sources within the Calaveras area. The department considers the proposed Folsom South Canal to be the logical supply facility for the valley floor section, as proposed by the United States Bureau of Reclamation. Since no projects to serve the San Joaquin Valley portion of the area are considered in this report, detailed results of land classification and water use studies discussed above have not been included herein. Tabulations of the basic field survey data are on file with the department and

similar data has been published in Bulletin No. 11, "San Joaquin County Investigation."

Available data on mineral content of surface and ground waters were supplemented by additional studies in order to determine the suitability of water supplies for irrigation and other beneficial uses. Studies were made to detect any change in ground water quality due to lower ground water levels.

Existing and probable future recreational uses of the area of investigation were studied. The consulting firm of Pacific Planning and Research was retained to study the outdoor recreational potential of proposed projects. Information obtained during this study was supplemented by studies conducted by the department.

The Department of Fish and Game, by service agreement with the department, conducted studies of the fishery potential of streams that would be affected by potential projects.

Engineering designs and estimates of costs were made for various sizes of projects under consideration. These estimates, with estimates of project benefits, were utilized in economic sizing studies. Reservoir operation studies were conducted to determine project yields of hydroelectric energy and water.

Economic studies were made to determine the benefits that would accrue to those projects which would be

feasible in the near future. These studies included:
(1) economic projections and analyses related to hydro-electric power projects, and (2) recreational and fish and wildlife analyses.

Area of Investigation

The Calaveras area comprises all of Calaveras County and portions of San Joaquin and Stanislaus Counties in the northeast corner of the San Joaquin Valley. The area extends from the Sacramento-San Joaquin Delta near Stockton to the Calaveras-Alpine boundary near the crest of the Sierra Nevada. Elevations in the area range from near-sea level, in the vicinity of Stockton, to over 8,000 feet in the eastern highlands of Calaveras County. Of the 1,169,000 acres in the Calaveras area, about 667,000 are in Calaveras County; about 89,000 acres are in Stanislaus County; and about 413,000 acres are in San Joaquin County. County boundaries are shown on Plate 1.

For purposes of this report, the area of investigation has been divided into three "units" which were established on the basis of the potential source of water supplies. The Valley Unit covers most of the San Joaquin Valley portion of the area and is mostly served at the present time from underlying ground water basins. The Main Stream Unit includes the foothill areas which would naturally be served

by the main streams which drain the area. The Tributary Unit includes all lands of the higher foothill and mountainous regions and which would naturally be served by water from streams tributary to the main streams. The locations and boundaries of the units are shown on Plate 2, "Area of Investigation."

The Main Stream and Tributary Units have been further divided into "subunits" or "service areas" as shown on Plate 2A, "Proposed Water Service Areas of Main Stream and Tributary Units." A more detailed description of the units and subunits of the area of investigation is presented in Chapter III, "Land and Water Use."

Natural Features

The topography of the Calaveras area varies from flat lands in the San Joaquin Valley in the lower west portion to rolling foothills in the central portion. Deeply incised canyons and rugged slopes exist in the higher eastern parts of the area near the crest of the Sierra Nevada.

Most of the valley lands in San Joaquin County are devoted to irrigated agricultural predominately in orchards, vineyards, permanent pasture, truck crops, and alfalfa. The lower foothills form gently-rolling, grass-covered meandering valleys. The higher foothills include increasingly steeper slopes, and more narrow canyons. For

the most part they are covered with heavy brush, stands of oak trees, and native grasses.

At an elevation of about 3,000 feet, the vegetation changes from oak to pine cover. Above 4,000 feet, to about 7,000 feet elevation, there are large, unbroken stands of marketable timber. At elevations above 7,000 feet, the cover consists of alpine growth amid bare granites and andesitic mud flows which extend to the highest elevations.

The Mokelumne and Stanislaus Rivers both rise in Alpine County at elevations in excess of 9,000 feet. Both rivers flow in a general south-westerly direction in diverging channels until they reach the valley floor, where they are some 35 miles apart. The Calaveras River rises at an elevation above 6,000 feet and drains the wedge-shaped area between the diverging Mokelumne and Stanislaus Rivers.

Geology

The Calaveras area is located on the western slope of the Central Sierra Nevada and extends into the great valley of California. The older rocks in the area are resistant pre-Tertiary metamorphic and intrusive igneous rocks, locally of unequal strength and complex structure. These rocks are often referred to as the bedrock series and include schist, quartzite, slate, crystalline limestone, metavolcanic rocks, granitic rocks, and ultrabasic rocks. Overlying the bedrock series are essentially undeformed

geologic materials of Tertiary age and younger. These materials include the sediments of the Ione formation, the rhyolitic pyroclastics and sediments of the Valley Springs formation; the andesitic debris of the Mehrten formation; all the older river channel deposits, glacial deposits; recent stream deposits; and flood plain and valley fill deposits of the San Joaquin Valley. The geologic features described herein are delineated on Plate 5, "Regional Geology of the Calaveras Area."

The geologic history of the Sierra Nevada is illustrated by present geologic conditions within the area of investigation. The bedrock series was originally a thick sequence of marine sedimentary and volcanic rocks which was later folded and faulted into an ancestral Sierra. This activity was accompanied by intrusion of ultrabasic rocks, followed by an invasion and engulfing of these rocks by great volumes of granitic magma. The region was eroded by middle Tertiary time to an area of moderate or low relief, and then was blanketed by volcanic rocks and sediments of the Valley Springs and Mehrten formations. Faulting, tilting, and uplift of the Sierra block, which occurred primarily during late Tertiary time, formed an extremely steep eastern escarpment and resulted in the carving of deep canyons by youthful streams on the otherwise gentle (about 2°) western slope. Many of the streams have incised

through the Tertiary volcanic rocks, cutting deeply into the underlying bedrock series. Additional sculpturing of the crest of the range and the canyons in the higher elevations was accomplished by glaciers during the Pleistocene epoch.

Soils

The soils of the Calaveras area may be segregated into the following four broad groups: (1) basin soils, (2) recent alluvial soils, (3) older valley fill soils, and (4) upland soils. The basin soils are found on the valley floor in the Delta region and extend eastward, gradually changing to the recent alluvial fan as the elevation increases. These alluvial soils change to the older valley fill soils in the lower elevation foothills. The higher foothills and mountainous areas are overlain by the upland group of soils.

The basin soils of the Delta are fine textured clays, some of which contain a high percentage of organic matter. These soils generally exhibit poor internal drainage characteristics but are extremely fertile and friable and are extensively farmed to a wide variety of shallow-rooted, summer-season field and truck crops. In many areas of the Delta the surface of these soils is at or below sea level. An extensive network of levees and drains protect these fields from inundation.

The recent alluvial soils were formed by the depositing of materials eroded from higher elevations in the watershed and transported by the streams that transect the area. These soils are characteristically well drained, of coarse to medium texture, and are utilized for the growth of a multitude of climatically adapted crop types, including deciduous orchard, vineyard, and truck and field crops.

The older valley fill soils are similar to the recent alluvial soils in that they were also formed by upstream erosion and subsequently transported and deposited by waters of the area. However, this group of soils has undergone extreme profile development, resulting in the formation of dense clay or hardpan subsoil layers which critically limit the movement of soil moisture and plant root development. Typically, these soils occur on lands exhibiting a gently undulating to strongly rolling relief, with small mounds generally in evidence. The crop adaptability of these soils is limited to shallow-rooted crops such as pasture, rice, and some field crops.

The upland soils were formed in place from weathering and decomposition of parent rock materials. These soils extend from the western foothills of Calaveras County eastward to the crest of the Sierra Nevada. Soil depths are largely dependent upon the amount of precipitation, and the weathering and decomposition of the parent rock materials.

Depths of soils vary from about 8 to 12 inches in the areas of low rainfall in the foothills, to extremely deep in the areas of high precipitation in the mountains. Due to relatively shallow soils, some rockiness, and a somewhat short growing season, the crop adaptability of the upland soils is restricted to deciduous orchards and pasture crops.

Climate

Because of wide ranges of elevation within the Calaveras area, precipitation and temperature extremes exhibit a wide range. As shown on Plate 3, the mean seasonal precipitation increases from about 16 inches on the floor of the San Joaquin Valley, to about 35 inches at Angels Camp, and over 55 inches at the extreme elevations in Calaveras County. The valley floor and foothill areas experience hot, dry summers and mild winters, while the higher, central area is characterized by moderate summers and cold winters. Above an elevation of about 5,000 feet, winters are long and usually severe, with heavy snowfall. At the Calaveras Big Trees weather station, at an elevation of 4,680 feet, the mean temperature is 48.8°F. and the mean annual precipitation is 53.36 inches. Practically all precipitation occurs during the months of October through April.

Variations in climate cause considerable differences in length of growing season. Within the area of

investigation, the growing season varies from about 270 days in the San Joaquin Valley to about 135 days in the higher regions.

Development

The development of the Calaveras area began around 1830 when a French trading company established a base camp near the present City of Stockton. From this base, fur trapping was conducted along the Sacramento and San Joaquin Rivers. The ruins of a former trading post of the present town of Mokelumne Hill are still in evidence.

With the discovery of gold in California in 1848 there was an influx of population, and Stockton became a trading center where ships could unload men and supplies bound for the busy mines in the mountains to the east. Calaveras and San Joaquin Counties were created during this period, in 1850, when the original 27 counties of California were formed. Stanislaus County was formed in 1854 from a portion of Tuolumne County.

The fertile lands of the San Joaquin Valley were utilized to grow hay and grain and to raise beef cattle for sale to the miners. Towns such as Mokelumne Hill, Angels Camp, and Murphy sprang up in the foothills and flourished during the boom era of the gold rush. By 1860 there were over 16,000 residents in Calaveras County. Water



for mining operations and urban supplies was conveyed by 15 ditches with a combined length of more than 300 miles.

Gold mining had passed its heyday by 1875, and there was a period of adjustment to the decline of mining and local agricultural activities. A period of development of large-scale lumbering, hydroelectric power establishments, and specialized agriculture followed the gold mining days. In more recent times there has been a revival of mining activities, the establishment of complex industrial and commercial enterprises, increased irrigation in agricultural operations, and the development of the recreational potential of the area.

The principal water development activities in the area of investigation have, in the past, been for the purpose of furnishing water to outside areas. A major portion of the waters of the Mokelumne River have been developed in Salt Springs and Pardee Reservoirs and are being further developed in Camanche Reservoir by the East Bay Municipal Utility District for its use. A large portion of the waters of the Calaveras River have been developed by Hogan Reservoir. This storage is utilized in the lower part of the area of investigation in San Joaquin County. The current construction of New Hogan Dam will provide for the further development of the waters of the Calaveras River. The waters of the Stanislaus River Basin have been



Agricultural and stock grazing lands are a principal source of income within the area of investigation



The current construction of New Hogan Dam will provide for the further development of the waters of the Calaveras River

extensively developed by the Pacific Gas and Electric Company, particularly on the South and Middle Fork, for use in the production of hydroelectric energy with incidental consumptive use in Calaveras and Tuolumne Counties. Various irrigation districts on the floor of the San Joaquin Valley have constructed works in the Stanislaus River Basin to develop water supplies for use within their respective districts.

Agriculture, particularly in San Joaquin and Stanislaus Counties, is the major economic activity in the Calaveras area. Other sources of income in the valley floor portion of the area of investigation are food processing industries, commercial establishments in the urban centers, and livestock grazing. Agricultural products include row crops, alfalfa, and deciduous fruits.

Within Calaveras County, the major sources of income are mining, lumbering, forest products industries, livestock grazing, agriculture, commercial establishments in the urban centers, recreation, and the production of hydroelectric energy. Agricultural products include irrigated pasture for sustaining beef and dairy herds, and some deciduous fruits, alfalfa, and grain. The forest products industries include sawmills and plywood plants. Commercial enterprises include the establishments necessary to provide goods and services to the surrounding areas.

Operators of agricultural and grazing lands in the foothills of San Joaquin and Stanislaus Counties between the Mokelumne and Stanislaus Rivers would be the chief beneficiaries of water development in the Calaveras area. These lands are now dry-farmed for livestock grazing and the production of grain. Substantial benefits from water development would also accrue to Calaveras County through domestic use of water, irrigation, and the production of hydroelectric energy.

A good transportation network crosses the Calaveras area. State Highway 49 traverses Calaveras County from north to south, and passing through the communities of Mokelumne Hill, San Andreas, Altaville, and Angels Camp. State Highway No. 4 crosses from west to east; it originates in Stockton, intersects State Highway No. 49 at Altaville, and continues eastward over the Sierra Nevada through Ebbetts Pass. State Highways Nos. 8 and 12 originate in Stockton and Lodi, respectively; they both extend to Valley Springs and then continue their respective routes to Mokelumne Hill and San Andreas. A network of county roads is adequate to serve as secondary transportation links. A branch-line of the Southern Pacific Company extends from Lodi to the Calaveras Cement Company plant near San Andreas.



CHAPTER II. WATER SUPPLY

The water supply of the Calaveras area originates as direct precipitation, surface and subsurface inflow, and water pumped from the Delta to the irrigated lands in the San Joaquin Valley. A portion of the surface water supply is used within the area of investigation, but most of it either drains from the area by way of the Mokelumne, Calaveras, and Stanislaus Rivers or is retained in storage reservoirs for use in outside areas.

The major portion of surface runoff occurs during late spring and early summer months from the melting of the Sierra Nevada snowpack. By late summer the streams have reached their annual minimum runoff and are sustained by springs and areas of effluent seepage. Both precipitation and runoff fluctuate widely from year to year.

Ground water, replenished by surface runoff, is the principal source of water for irrigation in the San Joaquin Valley. Most of the surface water applied to irrigation in the valley portion of the area of investigation comes from the Mokelumne, Calaveras, and Stanislaus Rivers; the remainder is pumped from the Delta. In Calaveras County, small irrigation supplies are obtained from direct diversion of unregulated streamflow and from

small water conservation works. Ground water in this county is not a significant source of irrigation water.

For the purposes of this report, the term "study period" refers to a period of years for which reliable records are available and during which the conditions of water supply and climate approximate those occurring during the mean period. The mean period for this report extends from the years 1905-06 to 1954-55.

The study period chosen for hydrologic analysis of ground water was the 7-year period 1952-53 through 1958-59. The study periods chosen for reservoir operation studies were the 15-year period 1920-21 through 1934-35, and the 35-year period 1920-21 through 1954-55. The shorter period was utilized during studies designed to resolve the size of reservoir that would most economically meet the water requirements of a given area; the longer period was used for more detailed analyses of a system of reservoirs designed to meet the water requirements of the entire area of investigation.

Precipitation

Precipitation on the Calaveras area is derived almost entirely from easterly moving storms that originate over the North Pacific. This precipitation is generally light on the valley floor and lower foothill areas and moderately heavy in the highlands near the crest of the

Sierra Nevada. Increasing elevation has a marked effect on the quantity of precipitation and on its occurrence as rain or snow.

Precipitation Stations and Records

There are 65 precipitation stations with unbroken records of 10 years or more in or adjacent to the Calaveras area. These stations are well distributed areally in the lower portions of the area, but much of the foothill region is unmeasured or contains stations of short duration. In the portions of the area above an elevation of about 5,000 feet precipitation is measured at snow courses.

The longest period of recorded precipitation is available for Stockton Fire Station No. 4, extending back to 1867. The seasonal precipitation recorded at the Stockton Fire Station No. 4 gage has varied from about 48 percent to 181 percent of the seasonal mean. The maximum seasonal precipitation of record at this station occurred during 1957-58, when 25.25 inches was recorded.

There are 22 snow courses located in or adjacent to the Calaveras area which are measured and maintained as part of the California Cooperative Snow Surveys. Eleven of these courses are located in the uplands of the Stanislaus River Basin, and an equal number are located in the uplands of the Mokelumne River Basin. Only four of these courses are located below an elevation of 6,000 feet. Three are

at an elevation above 8,000 feet. Because of the lack of precipitation stations at higher elevations the records obtained at the snow courses provide important precipitation data for the uplands of the Calaveras area and a reasonable means of predicting quantities of runoff from year to year.

Records of precipitation at the stations and snow courses in or adjacent to the Calaveras area have been published in bulletins of the U.S. Weather Bureau and the Department of Water Resources. Location of stations and snow courses are shown on Plate 3, "Lines of Equal Mean Seasonal Precipitation, 1905-06 through 1954-55."

The precipitation stations, with their elevations, periods, sources of record, and values of mean, minimum, and maximum seasonal precipitation, are presented in Table 1. Similar data for snow courses are presented in Table 2. In those instances where it was necessary, precipitation records of nearby stations.

As used in this report the term "mean period" is defined as a period chosen to represent conditions of water supply over a long series of years. In studies conducted during the Calaveras Area Investigation, the 50-year period 1905-06 to 1954-55 was selected as representative of mean conditions of precipitation. Minimum seasonal precipitation occurred in 1870-71 when 6.73 inches was recorded. Mean monthly distribution of precipitation, for stations

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION
AT SELECTED STATIONS IN OR NEAR THE CALAVERAS AREA

DWR reference: number :	Station	County	Elevation, in feet:	Period of record:	Source of record:	Mean seasonal precipitation, in inches:	Maximum and minimum seasonal precipitation year: Inches
B03301	Galt	Sacramento	46	1877-1916 1916-1959	USWB SPRR	15.27	1889-90 33.60 1923-24 8.75
B05032	Lodi	San Joaquin	40	1882-1959	USWB	16.09	1889-90 33.45 1912-13 8.08
B08560	Stockton FSH	San Joaquin	11	1867-1959	USWB	13.91	1957-58 25.25 1870-71 6.73
B04823	Lathrop-San Joaquin Bridge	San Joaquin	27	1910-1950	USWB	11.31	1940-41 16.49 1930-31 6.11
B05738	Modesto	Stanislaus	91	1871-1959	USWB	11.76	1957-58 23.04 1912-13 3.58
B09462	Waterford	Stanislaus	160	1889-1930	Modesto I. D.	12.89	1906-07 18.92 1923-24 4.91
B06303	Oakdale	Stanislaus	155	1880-1959	Private	14.32	1906-07 25.36 1912-13 7.29
B02970-02	Farmington	San Joaquin	111	1877-1918 1919-1954	USWB Private	14.28	1889-90 24.83 1911-12 7.93
B00637-02	Bellota 3E	San Joaquin	165	1934-1959	Private	17.45	1935-36 27.22 1938-39 11.00
B01813	Clements	San Joaquin	120	1933-1959	USWB	17.35	1957-58 27.09 1938-39 11.09
B09418	Wallace	Calaveras	197	1927-1959	USWB	19.29	1957-58 30.64 1930-31 10.32

TABLE 1 (continued)
MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION
AT SELECTED STATIONS IN OR NEAR THE CALAVERAS AREA

DWR reference: number :	Station :	County :	Eleva- tion, : :in feet:	Period of : :record :	Source of : :record :	Mean seasonal precipitation, :in inches/	Maximum and minimum seasonal precipitation :Precipitation year: Inches
B24283	Ione	Amador	287	1878-1915 1915-1957	USWB SPRR	21.34	1936-37 34.99 1923-24 10.50
B21428	Camp Pardee	Calaveras	658	1926-1959	FBMUD	20.83	1935-36 29.92 1932-33 12.72
B29235	Valley Springs	Calaveras	673	1888-1918 1920-1954 1956-1959	USWB FBMUD	20.75	1889-90 38.15 1923-24 10.08
B24351	Jenny Lind	Calaveras	250	1906-1943	USWB	18.92	1936-37 30.36 1923-24 8.81
B04590	Knights Ferry 2SE	Stanislaus	315	1906-1959	Private	17.68	1937-38 25.99 1923-24 8.75
B48353	Sonora	Tuolumne	1,830	1887-1959	USWB	31.31	1905-06 51.12 1923-24 13.67
B35511-01	Melones	Calaveras	750	1907-1927	USWB	28.25	1908-09 43.57 1923-24 13.06
B27702	San Andreas 2S	Calaveras	854	1924-1950 1950-1959	Private USWB	27.62	1955-56 42.17 1932-33 15.40
B25763-01	Mokelumne Hill	Calaveras	1,500	1882-1957	USWB	29.75	1889-90 54.59 1923-24 13.33
B22728	Electra P. H.	Amador	715	1904-1959	USWB	30.33	1906-07 50.97 1923-24 15.04
B29582	West Point	Calaveras	2,740	1894-1950	USWB	38.07	1894-95 59.91 1923-24 16.84

TABLE 1

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION
AT STATIONED STATIONS IN OR NEAR THE CALAVERAS AREA

Station	Station	County	Elevation, in feet	Period of record	Source of record	Mean seasonal precipitation, in inches	Maximum and minimum seasonal precipitation Precipitation year
B28150	Sheep Ranch	Calaveras	2,370	1937-1959	Private	37.11	1957-58 54.95 1958-59 21.39
B21277	Calaveras Big Trees	Calaveras	4,696	1930-1959	USWB	53.36	1951-52 76.38 1958-59 32.73
B27689	Salt Springs P.H.	Amador	3,700	1928-1959	USWB	43.69	1951-52 63.06 1930-31 26.53
B28781	Tamarack	Alpine	8,060	1899-1949	USWB	48.22	1906-07 93.99 1925-26 23.50
USWB - U. S. Weather Bureau, EBMUD - East Bay Municipal Utility District, SPRR - Southern Pacific Railroad Company							

1/ Mean seasonal precipitation values have been adjusted to the mean study period of 1905-06 to 1954-55.

TABLE 2

SNOW COURSES IN OR ADJACENT
TO THE CALAVERAS AREA

Snow courses	California reference number	Latitude and longitude	Eleva- tion, in feet	Period of record	Water content of snow on April 1		
					1930-59 average, in inches	Maximum	Minimum
					Year	Inches	Year
<u>Mokelumne River</u>							
Blue Lakes	129	38° 37.2' 119° 55.0'	8,000	1918-1960	35.6	1952 72.4	1934 13.8
Tragedy Springs	130	38° 38.3' 120° 09.0'	7,900	1938-1960	44.5	1952 88.0	1948 28.4
Wheeler Lake	131	38° 31.1' 119° 58.5'	7,800	1937-1960	52.4	1952 95.2	1939 32.0
Pacific Valley	132	38° 31.0' 119° 54.5'	7,500	1930-1960	37.0	1952 78.2	1931 16.4
Cornal Flat	133	38° 37.2' 120° 13.1'	7,300	1938-1960	39.7	1952 79.1	1951 20.8
Bear Valley Ridge #1	134	38° 32.1' 120° 13.1'	6,700	1930-1960	26.3	1952 58.9	1934 0
Laibeyard	135	38° 32.7' 120° 18.3'	6,600	1937-1960	32.4	1952 71.0	1947 13.6
Hay Station	136	38° 32.6' 120° 22.6'	5,600	1937-1960	9.8	1952 46.1	1/ 0
Antelope Springs	137	38° 31.0' 120° 27.0'	4,350	1939-1960	3.5	1952 25.5	2/ 0

SNOW COURSES IN OR ADJACENT
TO THE CALAVERAS AREA

Snow courses	California: reference number	Latitude and longitude	Eleva- tion, in feet	Period of record	Water content of snow on April 1		
					1930-59 : average, : in inches	Maximum :	Minimum :
					Year	Inches	Year
Highland Meadows	323	38° 29.2' 119° 48.1'	8,800	1952-1960	51.4	1958 73.4	1955 36.8
Bear Valley Ridge #2	339	38° 31.6' 120° 13.8'	6,600	1930-1960	28.2	1952 59.3	1934 9.6
<u>Stanislaus River</u>							
Lower Relief Valley	138	38° 14.7' 110° 46.0'	8,300	1930-1960	40.0	1952 68.3	1931 18.3
Soda Creek Flat	139	38° 15.7' 119° 40.6'	7,900	1931-1960	22.6	1938 44.1	1931 8.2
Eagle Meadow	140	38° 17.2' 119° 49.8'	7,500	1930-1960	25.0	1952 50.7	1951 7.9
Lake Alpine	141	38° 28.3' 120° 01.0'	7,500	1930-1960	41.7	1952 82.8	1931 18.0
Herring Creek	142	38° 13.8' 119° 57.3'	7,400	1937-1960	29.3	1952 62.7	1951 12.3
Relief Dam	143	38° 16.8' 119° 43.8'	7,300	1930-1960	20.6	1952 39.2	1951 6.6
Spicers	144	38° 23.6' 119° 59.2'	6,600	1937-1960	29.8	1952 66.4	1951 13.6

TABLE 2 (continued)

SNOW COURSES IN OR ADJACENT
TO THE CALAVERAS AREA

Snow course	:California: reference: number :	Latitude and longitude :	: Eleva- tion, : in : feet :	Period of record :	: Water content of snow on April 1			
					: 1930-59 : average, : : in inches :	: Maximum : : : : : Year :Inches:	: Minimum : : : : : Year :Inches	
Niagara Flat	145	38° 19.6' 119° 54.7'	6,500	1930-1960	21.7	1952 50.6	1931 7.0	
Big Meadow	146	38° 25.0' 120° 06.2'	6,500	1940-1960	29.4	1952 73.6	1959 13.3	
Cottage Spring	147	38° 21.3' 120° 12.5'	5,700	1938-1960	15.1	1952 56.1	3/ 0	
Dorrington	149	38° 18.3' 120° 16.7'	4,800	1938-1960	6.4	1952 38.4	4/ 0	

1/ Minimum water content of "0" was recorded in 1941, 1942, 1943, 1947, 1955, 1957, and 1959.

2/ Minimum water content of "0" was recorded in 1940, 1941, 1942, 1943, 1944, 1947, 1950, 1953, 1954, 1955, 1956, and 1957.

3/ Water content of "0" was recorded in 1940, 1947, 1957, and 1959.

4/ Water content of "0" was recorded in 1939, 1943, 1945, 1947, 1951, 1955, 1956, 1957, and 1959.

representative of both the valley and mountainous portions of the Calaveras area, is shown in Table 3. Recorded seasonal precipitation at selected stations in the area of investigation is shown in Table 4.

Quantities of Precipitation

Estimates of seasonal quantities of precipitation were determined for the San Joaquin Valley portion of the area of investigation as an aid in estimating current ground water storage conditions. Table 5 shows estimates of the mean seasonal depth and quantity of precipitation, as determined by:

1. Plotting recorded or estimated mean seasonal precipitation for all stations in or adjacent to the area and drawing lines of equal mean seasonal precipitation, or isohyets, as shown on Plate 3. As shown in Table 5, the weighted mean seasonal depth of precipitation on the San Joaquin Valley area was 15.4 inches.

2. Multiplying the areas between isohyets, in acres, by the average depths of precipitation between the isohyets, in feet, to derive the mean quantity of precipitation, in acre-feet. This amounted to approximately 462,000 acre-feet per season.

3. Seasonal quantities of precipitation during the seven-year study period were estimated by correlating these estimates for the mean period with the recorded precipitation at Stockton, Lockeford, and Woodward. As shown in Table 5, this amounted to approximately 477,000 acre-feet per season.

TABLE 3

MEAN MONTHLY DISTRIBUTION OF PRECIPITATION
AT STOCKTON AND CALAVERAS BIG TREES
(1905-06 through 1954-55)

Month	Precipitation, in inches and percent of annual total			
	Stockton		Calaveras Big Trees	
	Inches	Percent	Inches	Percent
	:	:	:	:
July	0.0	0.0	0.0	0.0
August	0.0	0.0	0.0	0.0
September	0.2	1.4	0.5	1.0
October	0.6	4.3	2.6	4.8
November	1.3	9.4	5.2	9.7
December	2.7	19.3	8.8	16.5
January	3.0	21.8	10.8	20.1
February	2.3	16.8	9.5	17.8
March	2.1	15.2	9.1	17.0
April	1.0	7.1	4.3	8.2
May	0.5	3.8	2.0	3.7
June	<u>0.1</u>	<u>0.9</u>	<u>0.6</u>	<u>1.2</u>
TOTAL	13.8	100.0	53.4	100.0

TABLE 4

RECORDED SEASONAL PRECIPITATION AT SELECTED STATIONS
IN THE CALAVERAS AREA
(In inches of depth)

Season	: Stockton	: Valley Springs	: West Point	: Calaveras Big Trees
1867-68	20.71	- <u>1/</u>	-	-
1868-69	16.45	-	-	-
1869-70	7.64	-	-	-
1870-71	6.73	-	-	-
1871-72	20.80	-	-	-
1872-73	13.28	-	-	-
1873-74	15.17	-	-	-
1874-75	11.14	-	-	-
1875-76	18.26	-	-	-
1876-77	7.10	-	-	-
1877-78	18.76	-	-	-
1878-79	11.46	-	-	-
1879-80	15.34	-	-	-
1880-81	14.68	-	-	-
1881-82	9.69	-	-	-
1882-83	15.26	-	-	-
1883-84	20.36	-	-	-
1884-85	9.59	-	-	-
1885-86	17.39	-	-	-
1886-87	7.83	-	-	-
1887-88	10.81	-	-	-
1888-89	12.99	14.58	-	-
1889-90	22.37	38.15	-	-
1890-91	10.09	19.49	-	-
1891-92	12.21	19.03	-	-
1892-93	15.89	28.33	-	-
1893-94	15.83	36.32	-	-
1894-95	19.78	33.80	59.91	-
1895-96	14.61	20.88	40.98	-
1896-97	12.62	30.35	46.17	-
1897-98	6.94	12.34	22.17	-
1898-99	14.40	17.02	34.47	-
1899-00	16.29	23.00	39.70	-

TABLE 4 (continued)

RECORDED SEASONAL PRECIPITATION AT SELECTED STATIONS
IN THE CALAVERAS AREA
(In inches of depth)

Season	: Stockton	: Valley Springs	: West Point	: Calaveras Big Trees
1900-01	16.74	25.09	53.07	-
1901-02	14.03	21.94	38.02	-
1902-03	14.54	26.03	44.02	-
1903-04	14.23	30.02	52.68	-
1904-05	18.19	29.89	38.19	-
1905-06	18.68	28.52	57.06	-
1906-07	22.49	35.76	58.39	-
1907-08	11.09	14.32	22.71	-
1908-09	15.89	25.53	46.68	-
1909-10	13.81	23.30	39.56	-
1910-11	19.93	34.47	57.54	-
1911-12	9.06	13.35	25.17	-
1912-13	7.30	13.19	28.27	-
1913-14	17.89	26.37	48.91	-
1914-15	17.46	25.95	44.17	-
1915-16	18.04	-	41.90	-
1916-17	10.87	-	35.91	-
1917-18	8.79	-	31.21	-
1918-19	15.89	-	30.40	-
1919-20	7.79	-	31.03	-
1920-21	15.06	23.28	46.56	-
1921-22	14.66	20.89	39.23	-
1922-23	16.71	22.65	41.12	-
1923-24	6.81	10.08	16.84	-
1924-25	18.04	23.69	42.60	-
1925-26	12.81	13.76	28.84	-
1926-27	15.35	21.48	46.03	-
1927-28	11.47	19.09	39.63	-
1928-29	9.72	17.83	31.78	-
1929-30	10.52	16.16	29.05	39.49 ^{2/}

TABLE 4 (continued)

RECORDED SEASONAL PRECIPITATION AT SELECTED STATIONS
IN THE CALAVERAS AREA
(In inches of depth)

Season	: Stockton	: Valley Springs	: West Point	: Calaveras Big Trees
1930-31	9.50	12.33	22.86	33.25
1931-32	11.95	19.16	38.75	61.30
1932-33	9.27	13.71	24.20	38.25
1933-34	9.95	17.75	29.34	35.66
1934-35	14.61	22.46	44.65	57.21
1935-36	18.08	27.52	50.35	62.77
1936-37	18.89	26.61	39.14	59.26
1937-38	18.09	28.47	54.17	76.75
1938-39	10.96	14.01	24.76	33.49
1939-40	18.58	23.33	47.57	61.78
1940-41	18.40	20.98	43.49	59.85
1941-42	19.69	24.45	47.91	68.64
1942-43	16.55	-	49.51	71.41
1943-44	12.45	-	29.96	38.63 ^{2/}
1944-45	14.40	-	40.51	61.03 ^{2/}
1945-46	13.14	17.88	37.37	56.16
1946-47	9.13	14.57	28.61	42.40
1947-48	11.37	23.07	38.46	53.29
1948-49	11.12	-	30.24	42.28
1949-50	10.57	-	-	53.02
1950-51	17.13	-	53.86	71.59
1951-52	19.56	30.03	49.69	76.38
1952-53	12.07	-	33.29	45.17
1953-54	10.56	15.36	31.38	44.87
1954-55	14.26	-	27.54	36.15
1955-56	18.55	-	50.01	71.35 ^{2/}
1956-57	12.57	-	33.20	46.93 ^{2/}
1957-58	25.25	-	52.06	71.93

^{1/} Indicates no record.

^{2/} Partial estimate.

TABLE 5

ESTIMATED SEASONAL DEPTH AND TOTAL QUANTITY OF
PRECIPITATION ON SAN JOAQUIN AREA GROUND WATER UNIT

Season	Precipitation index	Precipitation	
		Depth, in inches	Quantity, in acre-feet
1952-53	84	12.9	388,300
1953-54	77	11.9	356,000
1954-55	97	15.7	445,800
1955-56	128	19.7	589,700
1956-57	87	13.4	402,700
1957-58	181	27.9	837,800
1958-59	68	10.5	316,400
Average for 7-year base period	103	15.9	476,800
Mean for 50- year period 1905-06 through 1954-55	100	15.4	461,700

The estimated seasonal depth and quantity of precipitation on the Main Stream and Tributary Units are presented in Table 6. The procedure for evaluating these factors was the same as outlined above.

The term "precipitation index," as used in Tables 5 and 6, refers to the ratio of the amount of precipitation during a given year to the mean seasonal amount, expressed as a percentage.

Runoff

Runoff from rainfall and snowmelt in the Mokelumne, Calaveras, and Stanislaus River Basins constitutes the only significant source of water available for development for use in the foothill and mountainous portions of the Calaveras area.

This runoff has been extensively developed for use outside the area of investigation, mainly in the San Joaquin Valley and East Bay Municipal Utility District. However, a substantial portion of the runoff is unregulated and wastes from the area of investigation, particularly during wetter years, thus constituting a potential source of water to meet future requirements.

TABLE 6

ESTIMATED SEASONAL DEPTH
AND TOTAL QUANTITY OF PRECIPITATION
ON MAIN STREAM AND TRIBUTARY UNITS

Season	Main stream unit			Tributary Unit		
	: Precipi-	Precipitation		: Precipi-	Precipitation	
	: tation	: Depth,	: Quantity,	: tation	: Depth,	: Quantity,
	: index	:in inches:	:in acre-feet:	: index	:in inches:	:in acre-feet
1952-53	87	15.0	260,400	98	28.7	1,042,200
1953-54	78	13.4	233,300	85	24.9	907,000
1954-55	91	15.7	272,900	80	23.4	850,400
1955-56	126	21.7	377,000	139	40.7	1,478,300
1956-57	85	14.6	254,100	90	26.4	959,400
1957-58	160	27.5	477,000	143	41.9	1,521,900
1958-59	70	12.0	208,300	70	20.5	745,700
Average for 7-year base period	100	17.2	298,700	101	29.6	1,077,100
Mean for 50- year period 1905-06 through 1954-55	100	17.2	298,700	100	29.3	1,064,000

Stream Gaging Stations and Records

The records of streamflow for the Mokelumne, Calaveras, and Stanislaus Rivers are sufficiently numerous, long, and reliable to be used as a base for hydrologic analyses. There is, however, a paucity of records for most of the tributaries to the three rivers. To estimate runoff of these tributaries it was necessary to extend existing short-term records or to compute runoff for ungaged streams by correlative methods with nearby stations having records covering the mean period.

Stream gaging stations pertinent to the hydrology of the Calaveras area, together with their reference numbers, drainage areas, and periods and sources of record, are presented in Table 7. Reference numbers for all stations as shown on Plate 3 and listed in Table 7 have been assigned by the Department of Water Resources.

Runoff Characteristics

Runoff from the Mokelumne and Stanislaus River Basins is derived, for the most part, from snowmelt. As a result, peak flows of these streams are reached in the spring and early summer months, and low flows occur during late summer months. The maximum elevations of the Calaveras River Basin, however, are considerably lower than those of



East Bay Municipal Utility District weather station at Camp Pardee



U.S. Geological Survey stream gaging station, South Fork Makelumne River near West Point

STREAM GAGING STATIONS IN THE CALAVERAS AREA

DWR reference : number :	Stream	Station	Drainage : area, in : square miles :	Period : of : record :	Source
<u>Mokelumne River and Tributaries</u>					
B21375	Mokelumne River	near Mokelumne Hill	538.0	1903-04	USGS
B21170	Mokelumne River	at Lancha Plana	584.0	1927-59	USGS
B02130	Mokelumne River	near Clements	630.0	1926-59	USGS
				1904-51	USGS
				1951-55	DWR
B94300	Mokelumne River	at Woodbridge	644.0	1955-59	USGS
B94980	Woodbridge Canal	at Woodbridge	--	1924-57	USGS
B23100	Middle Fork Mokelumne River	at West Point	67.2	1926-59	USGS
B24100	South Fork Mokelumne River	near West Point	73.8	1911-59	USGS
				1933-59	USGS
B01510	Dry Creek	near Galt	346.0	1926-33	USGS
B01520	Dry Creek	near Galt	325.0	1933-39	EBMUD
				1941-59	USGS
<u>Calaveras River and Tributaries</u>					
B26300	Esperanza Creek	near Mokelumne Hill	16.7	1951-59	USGS
B26200	Jesus Maria Creek	near Mokelumne Hill	34.7	1950-59	USGS
B26150	North Fork Calaveras River	near San Andreas	85.7	1950-59	USGS
B26100	Murray Creek	near San Andreas	23.5	1950-59	USGS
B26250	Calaveritas Creek	near San Andreas	53.3	1950-59	USGS
B27150	San Antonio Creek	near San Andreas	46.6	1950-59	USGS
B27200	San Domingo Creek	near San Andreas	27.1	1950-59	USGS
B27100	South Fork Calaveras River	near San Andreas	118.0	1950-59	USGS
B25200	Cosgrove Creek	near Valley Springs	20.6	1929-59	USGS
B02590	Calaveras River	at Jenny Lind	395.0	1907-59	USGS
B02555	Calaveras River	at Bellota	--	1948-59	DWR
B02560	Mormon Slough	at Bellota	--	1948-59	DWR
B02520	Calaveras River	near Stockton	--	1948-59	DWR

TABLE 7 (continued)
STEAM GAGING STATIONS IN THE CALAVERAS AREA

DWR reference number :	:	:	:	Drainage : area, in : square miles:	Period : of : record	Source : of : record
	Stream	Station				
<u>Stanislaus River</u>						
B22300	North Fork Stanislaus River	below Silver Creek	29.2	1952-59	USGS	
B32150	Highland Creek	below Spicer Meadows Reservoir	43.0	1952-59	USGS	
B32100	North Fork Stanislaus River	near Avery, California	163.0	1914-22 1928-59	USGS USGS	
<u>Minor Valley Streams</u>						
B02045	Bear Creek	near Lockeford	48.4	1930-33 1933-43 1943-59	USGS EBMUD USGS	
B02850	Duck Creek	at Farmington	25.9	1950-57	DWR	
B02870	Littlejohns Creek	at Farmington	193.0	1925-26 1942-44 1946-59	USGS USBR USCE	
B02920	Duck Creek Diversion	near Farmington	28.0	1951-59	USCE	
B02835	Duck Creek	near Stockton	--	1950-59	DWR	
B02805	French Camp Slough	near French Camp	--	1950-59	DWR	

USGS - U. S. Geological Survey, DWR - Department of Water Resources, EBMUD - East Bay Municipal
Utility District, USBR - U. S. Bureau of Reclamation, USCE - U. S. Corps of Engineers

the Mokelumne and Stanislaus River Basins. Consequently, snowmelt does not contribute as large a proportion to the runoff of the Calaveras River as does rainfall. Thus, the monthly and annual patterns of runoff of the Calaveras Basin closely approximate the monthly and annual variations in precipitation over the basin. Stream discharge will increase greatly within a few hours following major storms.

Continuous records of flow are available for the three aforementioned river basins, covering the mean period. The stream gaging station on the Mokelumne River near Clements has been in existence since October 1904; the station on the Calaveras River at Jenny Lind since January 1907; and the station on the Stanislaus River at or near Knight's Ferry has existed since 1903. This latter gaging station was located at Knight's Ferry from 1903 to 1915, and was maintained slightly upstream from Knight's Ferry from 1915 to 1932. In 1931 a second gage was added at a point just below Melones Powerplant where it exists today. In 1957 a new gage was installed at Tulloch Reservoir near Knight's Ferry in order to determine the operation of this reservoir.

Flow of the Mokelumne River above the valley floor is impaired by Pardee, Salt Springs, and Bear River Reservoirs. The impairments to the flow of the Calaveras River above Hogan Reservoir are negligible. The Stanislaus

River flow is impaired by developments of the Pacific Gas and Electric Company and by the Oakdale and South San Joaquin Irrigation Districts.

Estimates of the natural runoff of the Mokelumne, Calaveras, and Stanislaus Rivers were included in Bulletin No. 1 for the period 1894-95 through 1946-47. For the purposes of this investigation, these estimates have been revised in the light of more recent data and extended to include the period 1947-48 through 1954-55.

Variations in annual and instantaneous runoff may be illustrated from recorded flows. During the period 1907-08 to 1958-59, the maximum recorded annual flow of the Mokelumne River near Clements occurred in 1910-11 and amounted to 1,500,000 acre-feet. Maximum recorded instantaneous flow was 28,800 second-feet on November 21, 1950. During July and August of 1934, there were periods when the flow dropped to zero.

The maximum recorded annual flow of the Calaveras River at Jenny Lind occurred during 1910-11, and amounted to 539,000 acre-feet. The minimum recorded annual flow was 13,400 acre-feet in 1930-31. The maximum recorded instantaneous flow was 50,000 second-feet on January 31, 1911. During the late summer months of most years, the flow drops to zero.

The maximum recorded annual flow of the Stanislaus River at Knight's Ferry occurred during 1906-07, the total

being 2,780,000 acre-feet. The minimum recorded annual flow occurred in 1923-24 and amounted to 250,000 acre-feet. The maximum recorded instantaneous flow was 64,500 second-feet on March 19, 1907. Flows of less than one second-foot have been recorded on many occasions. A period of zero flow occurred in December 1912, during the initial filling of Goodwin Reservoir.

Recorded and estimated natural annual flows for selected stations in the Calaveras area are presented in Table 8.

Quantity of Runoff

Quantitative determinations of runoff in the Calaveras area were made for the purposes of evaluating potential water conservation projects and for the hydrologic estimates of the San Joaquin area ground water basin. Available records of streamflow for the base periods were sufficient to make these determinations. Natural runoff at existing gaging stations was computed by making corrections for impairments above the existing stations. Computations for specific locations in the area of investigation, where records were of short-term duration or nonexistent, were based on precipitation information or made by correlation with nearby gaging stations having records for the desired period. The correlations employed in these determinations were restricted to drainage areas having similar patterns

TABLE 8

RECORDED AND ESTIMATED NATURAL ANNUAL FLOWS
AT SELECTED STATIONS IN THE CALAVERAS AREA
(In thousands of acre-feet)

Season :	Middle Fork : Mokelumne River : : at West Point, :	South Fork : Mokelumne River : : near West Point, :	recorded 1/ :	recorded 1/ :	Recorded:	Natural:	Calaveras : River at : Jenny Lind, :	North : Stanislaus River : near Avery, :	Stanislaus : River near : Knights Ferry 2/ :
	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	Recorded:
1907-08	22	28	475	480	72	191	611		
1908-09	77	94	1,160	1,180	365	438	1,890		
1909-10	63	79	906	921	187	385	1,370		
1910-11	96	115	1,500	1,505	539	497	2,320		
1911-12	19	25	393	402	63	182	587		
1912-13	17	22	423	438	31	186	564		
1913-14	87	105	1,080	1,090	228	425	1,760		
1914-15	52	66	823	838	245	358	1,270		
1915-16	74	91	1,030	1,040	299	480	1,590		
1916-17	57	73	868	876	295	345	1,360		
1917-18	29	37	521	528	177	227	804		
1918-19	24	31	590	597	93	213	749		
1919-20	24	31	464	468	83	215	713		
1920-21	51	65	865	871	215	391	1,230		
1921-22	57	73	919	925	220	353	1,432		
1922-23	40	51	703	709	171	258	1,100		
1923-24	5	9	182	187	18	88	250		
1924-25	42	54	824	835	159	365	1,200		
1925-26	17	22	374	377	65	191	596		
1926-27	52	67	877	898	181	331	1,300		
1927-28	36	47	639	642	130	244	922		
1928-29	15	20	288	343	41	152	494		
1929-30	19	24	300	463	67	219	688		

RECORDED AND ESTIMATED NATURAL ANNUAL FLOWS
AT SELECTED STATIONS IN THE CALAVERAS AREA
(In thousands of acre-feet)

Season :	Middle Fork : : recorded 1/ :	South Fork : : recorded 1/ :	Mokelumne River : : at West Point, near West Point, :	Mokelumne River : : Clements :	Calaveras : : River at Jenny Lind, :	North Fork : : Stanislaus River, near Avery, :	Stanislaus River : : Knights Ferry 2/ :
				Recorded:Natural:recorded 1/ :	Recorded 1/ :	recorded 1/ :	Recorded:Natural
1930-31	5	7	187	216	13	94	300 309
1931-32	35	45	492	760	139	350	1,290 1,327
1932-33	15	20	382	407	32	181	597 2/ 625
1933-34	10	14	297	360	58	134	404 419
1934-35	38	50	540	732	150	339	1,181 1,221
1935-36	53	74	860	929	286	366	1,310 1,375
1936-37	47	64	674	735	232	300	1,090 1,133
1937-38	95	125	1,208	1,303	372	548	2,008 2,109
1938-39	16	21	413	341	33	151	535 529
1939-40	55	73	734	901	208	379	1,389 1,431
1940-41	54	71	778	866	202	381	1,307 1,341
1941-42	68	85	934	1,012	200	405	1,448 1,502
1942-43	76	90	999	1,054	276	392	1,524 1,579
1943-44	25	30	386	460	77	182	668 686
1944-45	42	57	666	799	154	338	1,245 1,286
1945-46	46	56	646	761	117	323	1,149 1,479
1946-47	18	27	305	404	49	185	610 624
1947-48	31	41	461	649	82	270	861 887
1948-49	25	36	408	529	80	215	718 749
1949-50	42	52	607	766	120	308	1,045 1,088
1950-51	86	101	1,107	1,234	306	462	1,672 1,743
1951-52	106	125	1,190	1,352	334	504	1,867 1,939
1952-53	43	50	513	670	89	290	960 989
1953-54	36	43	464	563	74	239	869 892
1954-55	27	34	336	491	92	187	658 686

TABLE 8 (continued)

RECORDED AND ESTIMATED NATURAL ANNUAL FLOWS
AT SELECTED STATIONS IN THE CALAVERAS AREA
(In thousands of acre-feet)

Season	Middle Fork :		South Fork :		Mokelumne :		Calaveras :		North Fork :		Stanislaus :	
	Mokelumne River:		Mokelumne River:		River near :		River at :		Stanislaus River:		River near :	
	: at West Point,:		near West Point,:		Clements :		Jenny Lind,:		near Avery, :		Knights Ferry 2/ :	
	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	Recorded: 1/ :	Natural: recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	recorded 1/ :	Recorded: 1/ :	Natural
1955-56	96	113	1,114	1,284	314	518	1,829	1,893				
1956-57	38	47	494	621	70	267	770	798				
1957-58	84	108	914	1,084	352	432	1,607	1,681				
1958-59	22	28	254	380	58	169	642	667				
Average for the 50-year period 1907-08 through 1956-57	44	56		735	162	301						1,113

1/ Recorded flow was assumed to be equal to natural flow.

2/ Flows from 1932-33 on, are Stanislaus River below Melones Powerhouse.

of precipitation, topography, monthly distribution of runoff, elevation, and other factors affecting streamflow characteristics.

For the ground water hydrologic estimate of the San Joaquin ground water area, values of measured and estimated annual surface inflow to and outflow from the basin were compiled. These values are presented in Table 9.

Imported and Exported Water

Water is exported by the East Bay Municipal Utility District from the Mokelumne River Basin for use along the east shore of the San Francisco Bay through an export conveyance system with a capacity of 310 second-feet, or about 200,000,000 gallons daily. Current (1963) additions to this system will increase its capacity to 504 second-feet, or about 325,000,000 gallons per day.

The Pacific Gas and Electric Company operates the Amador Canal to divert water from the Mokelumne River for irrigation and domestic use in Amador County. Water rights for this diversion amount to 20,000 acre-feet annually, at a rate not to exceed 30 second-feet.

Water is exported from the South Fork Stanislaus River through the Lyons-Phoenix system of the Pacific Gas and Electric Company for energy generation in the Phoenix Powerplant and for consumptive use in the vicinity of

TABLE 9

MEASURED AND ESTIMATED ANNUAL SURFACE INFLOW
TO AN OUTFLOW FROM SAN JOAQUIN GROUND WATER AREA
(In acre-feet)

Source	Annual (March 1 through February 28)							Average for seven-
	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	year study period
Inflow								
Mokelumne River	1,057,600	493,400	485,300	659,000	748,400	524,200	860,200	689,700
Calaveras River	200,900	53,900	111,900	297,400	60,400	154,100	296,600	167,900
Littlejohns Creek	53,500	1,800	39,800	110,400	3,900	56,900	102,600	52,700
Bear Creek	7,200	500	6,800	18,100	1,500	9,400	23,000	9,500
Minor drainage	15,000	900	14,200	37,600	3,200	19,500	47,900	19,800
Pumped diversions	6,400	9,700	12,100	13,900	9,500	9,700	10,200	10,200
Outflow								
Mokelumne River	928,900	317,800	296,500	492,700	613,300	388,900	720,200	536,900
Calaveras River	24,200	5,500	5,800	20,300	5,900	9,200	28,000	14,100
Stockton Diversion								
Canal	145,600	9,100	75,000	256,200	13,100	111,300	220,100	118,600
French Camp Slough	52,100	12,700	42,600	111,000	14,600	70,400	136,000	62,800
Bear Creek	---	---	---	---	11,700	9,000	10,400	---

Sonora area is within the Tuolumne River Basin, the unused portion of this exported water eventually appears as inflow to the Tuolumne River Basin above Don Pedro Reservoir.

The Pacific Gas and Electric Company also operates the Utica Ditch system which diverts water from the North Fork Stanislaus River near Avery for the generation of hydroelectric energy in Calaveras County. None of the water diverted through this system is used outside the Calaveras area and most of it is returned to the Stanislaus River.

Ground Water

There are no ground water basins of significant size in the foothills and mountainous portions of the Calaveras area. However, the use of small amounts of ground water from limited ground water producing areas is common. Wells utilized in these areas often provide an insufficient supply during the fall months of water deficient years. The development of additional wells in these areas can be expected to result in lowering of water levels and reductions in the yield of existing wells.

The San Joaquin Valley portion of the area of investigation consists of the valley unit and portions of main stream unit at the lower elevations. The area is one of extensive agriculture, based in part on a water supply from a vast ground water basin of considerable storage

capacity. The characteristics, behavior, and safe yield of this ground water basin were investigated by the State Water Resources Board from 1948 to 1954, and reported on in Bulletin No. 11, "San Joaquin County Investigation," dated June 1955. Although additional study of ground water conditions in this area were made for this investigation, the results reported herein are limited to general conclusions. No plans have been formulated to serve water to this area because the proposed Folsom South Canal seems to be the most feasible supply facility.

In the Bulletin No. 11 studies the San Joaquin area was divided into the Calaveras, Littlejohns, East Mokelumne, and West Mokelumne units. These same units are shown on Plates 4A and 4B and were utilized during the Calaveras Area Investigation.

Since the publication by the State of Bulletin No. 11 in June 1955, ground water conditions in the San Joaquin area have not improved. A concluding statement from that report applies with equal emphasis at the present time (1963) and is accordingly repeated below.

"The present basic water problems in the San Joaquin Area are manifested in progressive, perennial lowering of ground water levels and in the threat of attendant degradation of the mineral quality of the ground water.

"Elimination of these problems, prevention of their recurrence in the future, irrigation of irrigable lands not presently served with water, and provision for anticipated future urban and industrial growth will

require the further development of water supplies in streams tributary to the area, or the importation of water supplies from other potential sources, or some combination thereof."

The ground water basin underlying the San Joaquin area, with a storage capacity of over 4,000,000 acre-feet between the levels of 25 and 200 feet below the ground surface, functions as a natural regulatory reservoir for a portion of the presently available water supply. It is estimated that about 85 percent of the irrigated lands in the area were served with water pumped from this reservoir during the 1958-59 season. The gross extraction of ground water in 1948-49 was about 381,000 acre-feet. Satisfactory wells with yields sufficient for irrigation purposes may be developed in all portions of the San Joaquin area.

The recent form of the free ground water surface is shown on Plate 4A, "Lines of Equal Depth to Ground Water," and Plate 4B, "Lines of Equal Elevation of Ground Water." Both of these plates represent conditions as measured in the spring of 1959. Corresponding data for the fall of 1952 are shown in Bulletin No. 11. The estimated average spring depth to ground water is presented in Table 10.

Because of the continuing development and extensive use of ground water in the San Joaquin area, ground water levels generally continue to fall. The average changes in levels of ground water in the four ground water units are shown in Table 11.

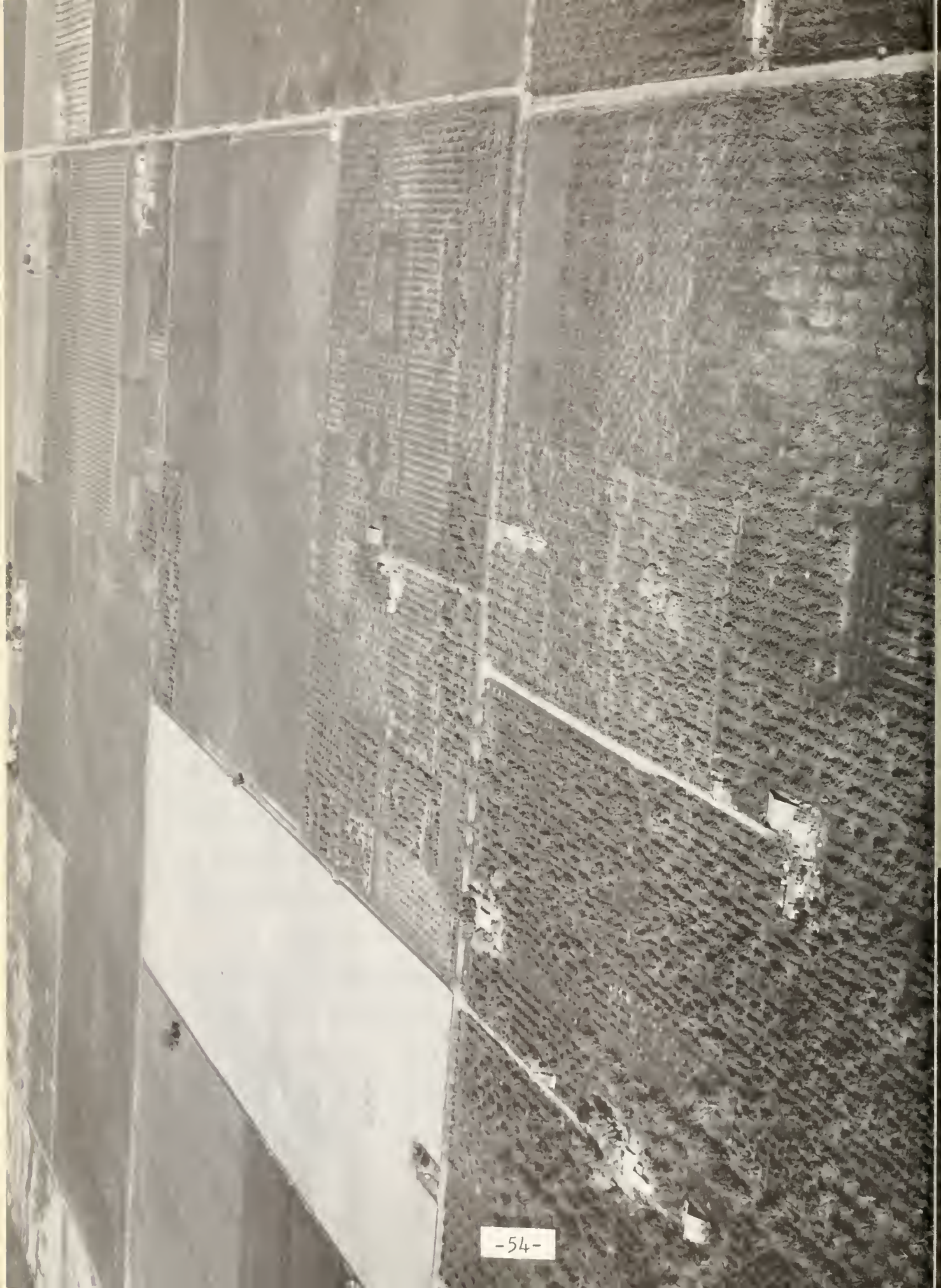


TABLE 10

ESTIMATED AVERAGE SPRING DEPTH TO
GROUND WATER IN THE SAN JOAQUIN AREA
(In feet)

Year	Western Mokelumne	Eastern Mokelumne	Calaveras	Littlejohns	Precip- itation index
1952 ^{1/}	6.9	56.6	46.9	29.8	1.39
1953	7.7	55.3	48.8	32.8	0.84
1954	13.4	63.6	51.5	37.2	0.77
1955	12.2	63.9	52.5	^{2/}	0.97
1956	10.4	63.9	53.8	41.3	1.28
1957	16.9	52.7	54.5	47.4	0.87
1958	12.7	59.5	58.3	47.6	1.82
1959 ^{1/}	12.1	63.1	57.4	53.3	0.68
1960 ^{1/}	14.7	67.0	63.0	55.7	-

- ^{1/} Depths derived by planimetering contours of equal depth. All others are arithmetic averages of available measurements.
^{2/} No measurements taken.

TABLE 11

ESTIMATED ANNUAL CHANGES IN SPRING GROUND WATER
ELEVATION IN UNITS OF THE SAN JOAQUIN AREA
(In feet)

Unit	Average 1952-59	1959-60
Western Mokelumne	-0.8	-2.6
Eastern Mokelumne	-0.9	-3.9
Calaveras	-1.5	-5.6
Littlejohns	-3.9	-2.4

A comparison is shown below between the safe yield of ground water from the San Joaquin area in 1960 and in 1952 as reported in Bulletin No. 11, from which publication the term is defined.

"The term 'safe ground water yield,' refers to the maximum rate of extraction of water from a ground water basin which, if continued over an indefinitely long period of years, would result in the maintenance of certain desirable fixed conditions. Commonly, safe ground water yield is determined by one or more of the following criteria:

"1. Mean seasonal extraction of water from the ground water basin does not exceed mean seasonal replenishment to the basin.

"2. Water levels are not so lowered as to cause harmful impairment of the quality of the ground water by intrusion of other water of undesirable quality, or by accumulation and concentration of degradants or pollutants.

"3. Water levels are not so lowered as to imperil the economy of ground water users by excessive costs of pumping from the ground water basin, or by exclusion of users from a supply therefrom."

The estimated safe ground water yield for the San Joaquin ground water area was estimated in Bulletin No. 11 to be approximately 266,000 acre-feet per season. The study made during the current investigation indicates that the safe yield, based on a normal water supply and the mean of ground water levels as they occurred during the 1952-59 period, has increased by approximately 40,000 acre-feet per season. Overdrafts on a ground water basin frequently

result in an apparent increase of the safe yield because the concomitant reduction of water level increases the gradient from neighboring ground water sources and results in an increase of subsurface inflow. Whether this truly represents an increase of safe yield of the basin depends on the degree to which the above-quoted criteria are met. The scope of the current investigation did not provide the answer to this question.

Since quantitative estimates of safe yield are functions of the cultural development pattern and water supply, and since the criteria for safe yield of a particular basin is subject to refinement as better records are collected, further revisions of safe yield estimates are to be expected. Field surveys of ground water conditions in this area have been conducted periodically and the results were published in Supplements I-IV to Bulletin No. 11 dated respectively from May 1956 to March 1959. Bulletin No. 66-60, "Quality of Ground Water in California, 1960, Part I, Northern and Central California," and Bulletin No. 77-59, "Ground Water Conditions in Central and Northern California," present the basic data of continuing ground water monitoring programs.



Water is diverted from the North Fork Stonislaus River through the Utica Ditch for use in Calaveras County



There is very limited use of ground water in the foothill regions of the Calaveras area

Water Quality

The surface waters of the Calaveras area are of excellent mineral quality and are well suited to all beneficial uses. The quality of water from all streams tested was satisfactory for most irrigation purposes. The samples also meet the U.S. Department of Public Health standards for drinking water.

Ground waters of the area of investigation are also generally of excellent mineral quality, and are well suited to all beneficial uses. It should be noted, however, that the quality of ground waters in areas of excessive drawdown may be measurably affected where the ground water area does not receive sufficient recharge to maintain a reasonably stable level. Tests conducted during 1962 in the Stockton area indicate a significant increase in some wells of the chloride content of the underlying fresh water supply. This chloride increase is probably the indirect result of excessive ground water pumpage. During the period 1962-63 to 1958-59, the water table dropped at the rate of about 1.5 feet per year in this area, which has reduced the pressure on the deeper brackish and saline waters, apparently allowing their upward migration and commingling with waters of the fresh water-bearing aquifers. More recent measurements of well levels indicate the rate of drawdown has been approximately five feet per year in Central Stockton.

Water Quality Criteria

Criteria adopted by the Department of Water Resources in evaluating mineral quality of water for municipal, domestic, irrigation, and fish and wildlife uses are presented below. These criteria are guides for the appraisal of water quality and, except for those constituents which are toxic to human beings, should be considered as suggested limiting values. Waters which exceed one or more of these limiting values need not be eliminated from consideration as a source of supply, but other sources of more acceptable quality should be investigated.

Domestic and Municipal Water Supply. The following tabulation presents the limiting concentrations of mineral constituents for drinking water as proposed by the U.S. Public Health Service and adopted by the State of California.

U.S. Public Health Service Drinking Water Standards, 1962

<u>Substance</u>	<u>Maximum Permissible Concentration (mg/l)</u>
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Flouride (F)	(See following table)
Lead (Pb)	0.05
Selenium	0.01
Silver (Ag)	0.05

Fluoride Concentrations*

Annual Average of Maximum: Recommend Control Limits - Daily Air Temperatures : Fluoride Concentrations in			
	mg/l		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	0.8	1.1	1.5
58.4-63.8	0.8	1.0	1.3
63.9-70.6	0.7	0.9	1.2
70.7-79.2	0.7	0.8	1.0
79.3-90.5	0.6	0.7	0.8

* When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit as shown. Where supplemental fluorides are added to drinking water, the average concentration shall be kept between the upper and lower limits as shown.

Even though hardness of water is not included in the above criteria, it is important in domestic and industrial uses. Excessively hard water used for domestic purposes causes increased consumption of soap and the formation of scale in pipes and fixtures. The following tabulation lists the standards of hardness as suggested by the U.S. Geological Survey.

Range of hardness, expressed as CaCO_3 , in ppm	Relative classification
0 - 60	Soft
61 - 120	Moderately hard
121 - 200	Hard
201 and above	Usually requires softening

Irrigation Water. Criteria for mineral quality of irrigation water used by the Department of Water Resources are developed at the University of California at Davis and at the U.S. Department of Agriculture Regional Salinity Laboratory at Riverside, California. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters may be suggested as follows:

Qualitative Classification of Irrigation Waters

	: Class 1	: Class 2 :	Class 3
	: excellent to	: good to :	injurious to
Chemical properties	: good	: injurious:	unsatisfactory
Total dissolved solids, in ppm	Less than 700	700-2000	More than 2000
Conductance, in Micromhos (EC x 10 ⁶ at 25°C)	Less than 1000	1000-3000	More than 3000
Chloride, in ppm	Less than 175	175-350	More than 350
Sodium, in percent of base constituents	Less than 60	60-75	More than 75
Boron, in ppm	Less than 0.5	0.5-2.0	More than 2.0

Class I irrigation water is suitable under most conditions for most crops. Class 2 irrigation water is of doubtful suitability for crops which have low salt tolerances such as citrus, deciduous fruits, some vegetables, and most clover grasses. Class 3 water is generally unsatisfactory for all crops except the more hardy plants such as cotton, sugar beets, and salt-tolerant forage grasses.

These criteria have limitations in actual practice. In many instances, water may be wholly unsuitable for irrigation under certain conditions of use and yet be completely satisfactory under other circumstances. Consideration should be given to such variables as soil permeability and drainage, temperature, humidity, rainfall, and other conditions that may affect the response of a crop to a particular quality of water.

Preservation and Protection of Fish and Wildlife.

A water of high quality is necessary for the preservation and protection of fish and wildlife. This high quality is necessary both for the proper environment of fish and the maintenance of naturally occurring food upon which fish depend for their sustenance.

Studies by various state and federal agencies show that there are many mineral and organic substances in relatively low concentrations which are harmful to freshwater fish and other aquatic life. Water quality criteria for maintenance of freshwater fishlife have been suggested by the Department of Fish and Game as follows:

1. Dissolved oxygen content not less than 85 percent of saturation.

2. Hydrogen-ion concentration (PH) ranging between 6.5 and 8.5.

3. Conductivity between 150 and 500 micromhos at 25°C and, in general, not exceeding 1,000 micromhos.

Additional studies have shown that fish and other species of aquatic life are particularly susceptible to any one of the following:

1. Mineral salts of high toxicity (such as mercury, copper, lead, zinc, cadmium, aluminum, nickel, trivalent and hexavalent chromium, and iron). Combinations of these metallic salts are sometimes considerably more toxic to fishlife than any one salt would be individually.

2. Detergents, poisons, and insecticides employed in agricultural pursuits.

3. Unusual temperature conditions. Normal range of water temperatures for cold-water fish lies between 32° and 65°F. For warm-water species, a desirable range is from 45° to 85°F, with an absolute maximum of 91°F.

4. Water discharges containing more than 15 ppm of ether soluble material.

Surface Water Quality

Analyses of surface water samples collected during 1959 from the Mokelumne, Calaveras, and Stanislaus River Basins have shown that the waters of these basins are of excellent mineral quality and are well suited for irrigation and other beneficial uses. These waters are characterized by a low content of total soluble minerals, chloride and boron, and by a low percent of sodium. The waters of the minor tributary streams in the area of investigation have a higher concentration of soluble minerals than the waters of the main streams but are well within the allowable

limits of Class 1 irrigation water. Selected mineral analyses of representative surface waters are presented in Table 12.

Ground Water Quality

Samples of water for quality analysis were collected from selected wells within the area of investigation. From the standpoint of irrigation criteria the mineral quality of water from these wells was generally excellent. However, on the basis of suitability for domestic use, water from some wells did not meet the standards prescribed by the U.S. Public Health Service. This situation occurs notably in the south-central portion of Calaveras County, where users attach water softeners to their wells. This precaution serves to bring the water within the desired softness for domestic use. One well in the vicinity of Valley Springs yields water that is unsuitable for any beneficial use.

Ground water of the San Joaquin ground water area was sampled from 80 sources in 1959. Of these 80 sources, only 7 yielded water which did not satisfy the criteria for domestic use or for Class 1 irrigation water. The ranges and average concentrations of selected mineral constituents of ground water samples are shown in Table 13.

TABLE 12

MINERAL ANALYSES OF REPRESENTATIVE SURFACE WATERS
OF THE CALAVERAS AREA

Location	Date of sample	: Conductance: : EC x 10 ⁶ : : at 25°C : ppm	Boron: Mineral constituents in equivalents/million									
			in :	Ca :	Mg :	Na :	+CC3 :	Cl :	SO ₄ :	NO ₃ :	Percent	
												sodium
<u>Calaveras River Basin</u>												
North Fork Calaveras River, T4N, R11E, Section 13	1/8/60	287.0	0.00	1.75	0.71	0.44	2.20	0.45	0.29	0.03	15.0	
South Fork Calaveras River, T4N, R11E, Section 24	1/8/60	233.0	0.00	1.35	0.93	0.40	2.00	0.34	0.40	0.00	14.0	
Calaveras River, T4N, R11E, Section 14	1/8/60	265.0	0.00	1.55	0.83	0.44	1.69	0.68	0.50	0.01	15.0	
San Antonio Creek, T5N, R15E, Section 21	8/19/59	71.6	0.04	0.33	0.19	0.13	0.64	0.01	0.00	0.01	19.0	
<u>Stanislaus River Basin</u>												
North Fork Stanislaus River at Boards Crossing	8/19/59	50.7	0.04	0.27	0.09	0.07	0.43	0.01	0.00	0.00	16.0	
Stanislaus River at Melones	1/27/60	72.0	0.01	0.42	0.12	0.10	0.54	0.02	0.05	0.01	15.0	
Mill Creek, T4N, R15E, Section 7	1/27/60	42.0	0.02	0.16	0.06	0.10	0.28	0.03	0.01	0.01	28.0	
Coyote Creek near Melones	1/27/60	314.0	0.02	1.65	1.33	0.22	2.95	0.15	0.16	0.00	7.0	
Arithmetic Average of all samples		153.4	0.02	0.85	0.44	0.22	1.25	0.14	0.14	0.00	16.5	
Maximum allowable limits for Class 1 water		1,000.0	0.50	1/	1/	1/	1/	5.00	1/	1/	60.0	

1/ No maximum limit specified.

TABLE 13

RANGES AND AVERAGE CONCENTRATIONS OF
MINERAL CONSTITUENTS OF GROUND WATER IN THE
SAN JOAQUIN VALLEY GROUND WATER AREA

<u>Constituents</u>	<u>Range</u>	<u>Average</u>
Conductance in micromhos per centimeter at 25°C	47 - 3780	453
Total dissolved solids in ppm	34 - 1980	309
Percent sodium	7 - 59	29
Boron in ppm	0.00 - 0.63	0.14
Total hardness in ppm	20 - 439	154

CHAPTER III. LAND AND WATER USE

The water resources of the Calaveras area have been developed extensively for both consumptive and non-consumptive purposes. Surface supply developments are utilized in Calaveras County for the production of hydro-electric energy, and recreational, domestic, and limited irrigational purposes. In the San Joaquin and Stanislaus County portions of the area of investigation, ground water has been extensively developed to support the thriving local agricultural economy.

The nature and extent of present and possible future water utilization and of requirements for additional water supplies in the Calaveras area are discussed in this chapter. In the discussion to follow, the area is divided into geographically homogeneous units and water service areas; the present and potential uses of the land are considered; and the present and future requirements for water supply deliveries are presented.

Units of Investigation and Water Service Areas

To facilitate the discussion of land and water use, the Calaveras area was divided into the Valley, Main Stream, and Tributary Units as delineated on Plate 2, "Area of Investigation." The Main Stream and Tributary



Port and City of Stockton showing urban, suburban, industrial and navigational use of water

Units were further divided into subunits or service areas as shown on Plate 2A, "Proposed Water Service Areas of the Main Stream and Tributary Units."

The Valley Unit

The Valley Unit consists of the lands on the San Joaquin Valley floor that lie within the area of investigation. Water supplies for this area are obtained from the underlying ground water basin and from supplies pumped from the Delta. Future supplemental supplies will be obtained from the proposed Folsom South Canal of the United States Bureau of Reclamation.

The Main Stream Unit

The Main Stream Unit consists of foothill lands within the area of investigation that can be served by gravity from major reservoirs located at lower elevations on the Mokelumne, Calaveras, and Stanislaus Rivers. This unit was divided into the Bachelor and Hogan Subunits.

The Bachelor Subunit. This subunit includes foothill lands located between the Stanislaus and the Calaveras Rivers that would best be served by gravity diversion from the Stanislaus River. It would also be possible to serve lands in the western portion of this subunit by pumping water from the proposed Folsom South Canal.

The Hogan Subunit. The service area consists of foothill lands lying between the Calaveras and Mokelumne Rivers that would best be served by gravity diversion from New Hogan Reservoir. Here, also, there are possibilities for serving some lands by pumping from the Folsom South Canal.

The Tributary Unit

The Tributary Unit encompasses the remainder of the area of investigation above the valley and foothill lands that could be served by gravity from the major main stream reservoirs. This unit is divided into the Lodgepole, West Point, Railroad Flat, Jesus Maria, Emery, San Andreas, Bear Mountain, Nassau, and Murphys-Angel Subunits.

The Lodgepole Subunit. The area is largely devoted to lands under forest management which are utilized for recreation. The water requirements of this area are mostly to supply summer homes, resorts, and camping grounds and may best be met by the construction of small local conservation and distribution works.

The West Point Subunit. The area includes all irrigable lands between the North and South Forks of the Mokelumne River. Supplemental water requirements for this area may be met by small developments on the Middle Fork Mokelumne River.

The Railroad Flat Subunit. This area encompasses lands south of the Mokelumne River that may be served by gravity flow from the South Fork Mokelumne River and the North Fork Calaveras River.

The Jesus Maria Subunit. This area contains irrigable lands in the Jesus Maria Creek Basin that may best be served by the construction of a local reservoir which, in turn, would be supplied by water diverted from the North Fork Stanislaus River.

The Emery Subunit. This area encompasses irrigable land in the vicinity of Sheep Ranch and Mountain Ranch that can best be served by water from a local regulation reservoir that would be supplied from a conduit extending from the proposed storage facility in the Jesus Maria Subunit.

The San Andreas Subunit. This area includes the town of San Andreas, the county seat of Calaveras County, and lands adjacent to the South Fork Calaveras River. This subunit may be served from an extension of the diversion system to Angels Powerplant, from the Emery Subunit, from the continued diversion of water from the South Fork Mokelumne River, or by any combination of these three possibilities.

The Bear Mountain Subunit. This area contains irrigable lands in the Bear Mountain Range and in Salt

Springs Valley. These lands may best be served by pumping from Salt Springs Reservoir and by replacing the water thus used with water from the proposed New Melones Canal, as the present service area of Salt Springs Reservoir lies below this canal.

The Nassau Subunit. This area includes irrigable lands lying between the Bear Mountain Subunit and the Murphys-Angel Subunit. This area may best be served by small local developments supplemented by pumping from Angels Creek or by gravity diversion from Angels Forebay.

The Murphys-Angel Subunit. This area is located along the west side of the Stanislaus River and its North Fork. This unit may best be served by diverting water from the North Fork Stanislaus River at the Ganns Diversion site.

Land Use

Predictions of the future water requirements in the Calaveras area are dependent upon estimates of future use of the land and projections of population. The first step in determining the future land use was to assess the nature and extent of present land use. Similarly the probable future land use was forecasted on the basis of land classification survey data which segregated lands in accordance with their suitability for irrigated agriculture and other uses.

Table 14 shows the rural and urban permanent population which is predicted for the Main Stream and Tributary Units by the year 2020. This estimate was developed from previous work done by the department. The detailed population estimates by type and service area were derived by considering the economic potential and adaptability of the lands.

The classification of lands of the Main Stream and Tributary Units is shown in Table 15. Corresponding data showing the present land use and the year 2020 predicted land use are presented in Table 16 and 17, respectively.

Land Use Classification

As an aid to land use predictions, lands of the Main Stream and Tributary Units were segregated into the following land use categories:

1. Irrigable agricultural lands.
2. Irrigable forest and range lands.
3. Urban and suburban lands.
4. Recreation lands.
5. Major park lands.
6. All other lands.

These major categories were subdivided into subclasses as discussed in the following sections.

TABLE 14

ESTIMATED PERMANENT POPULATION FOR YEAR 2020
IN THE MAIN STREAM AND TRIBUTARY UNITS

Subareas	:Urban and: :Suburban :	Rural	: Totals
Main Stream Subunits			
Bachelor	1,230	1,970	3,200
Hogan	<u>2,750</u>	<u>1,250</u>	<u>4,000</u>
SUBTOTAL	3,980	3,220	7,200
Tributary Subunits			
Bear Mountain	950	330	1,280
Emery	1,800	1,500	3,300
Jesus Maria	1,500	1,500	3,000
Lodgepole	1,500	2,500	4,000
Murphys Angels	20,000	7,000	27,000
Nassau	140	180	320
Railroad Flat	6,000	4,000	10,000
San Andreas	6,000	1,000	7,000
West Point	<u>4,000</u>	<u>3,200</u>	<u>7,200</u>
SUBTOTAL	41,890	21,210	63,100
TOTAL	<u>45,870</u>	<u>24,430</u>	<u>70,300</u>

TABLE 15

CLASSIFICATION OF LANDS OF THE MAIN STREAM AND TRIBUTARY UNITS
(In gross acres)

Land Class	Main Stream		Total Main:		Bear	Jesus	Tributary Subunits										Total	
	Subunits		Stream				Marphys	Railroad	San	West	Tributary	Angels	Nassau	Flat	Andreae	Point	Subunits	Totals
	Bachelor	Mogan	Subunits	Mountain	Emery	Mari	Lodge	poles										
IRRIGABLE AGRICULTURAL LANDS:																		
V	7,600	8,240	15,840	1,310	80	90	170	460	110	900	30	60					3,210	19,050
Vw	30	-	30	-	-	-	240	80	-	-	-	-	-	-	-	-	320	350
Vh	-	30	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
VL	-	30	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
VP	31,860	6,710	38,570	1,060	-	-	-	-	70	380	-	-	-	-	-	-	1,510	40,080
VR	110	20	130	30	-	-	-	100	-	-	-	-	-	-	-	-	130	260
VPR	-	300	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	300
H	-	3,170	3,170	120	740	830	570	2,910	-	950	80	780	-	-	-	-	6,980	10,150
HP	44,940	38,520	83,460	11,580	370	140	-	1,600	2,260	3,690	130	20	-	-	-	-	19,790	103,250
MR	-	-	-	70	140	240	810	680	30	120	210	240	-	-	-	-	2,540	4,700
MPR	290	1,390	1,680	1,890	10	-	10	310	30	770	-	-	-	-	-	-	3,020	4,700
M	-	50	50	70	790	1,080	820	1,100	-	1,480	10	2,780	-	-	-	-	8,130	8,180
MP	7,700	4,940	12,640	7,250	3,230	3,440	140	6,060	1,110	6,050	1,180	350	-	-	-	-	28,810	41,450
MR	-	-	-	90	120	280	1,570	720	-	120	10	530	-	-	-	-	3,440	3,440
MPR	80	800	880	2,140	200	-	80	2,650	340	2,730	1,110	-	-	-	-	-	9,250	10,130
SUBTOTALS	92,610	64,200	156,810	25,610	5,680	6,100	4,410	16,670	3,950	17,190	2,760	4,760	-	-	-	-	87,130	243,940
IRRIGABLE FOREST AND RANGE LAND																		
URBAN AND SUBURBAN LAND	40	440	480	580	630	210	40	11,210	-	4,320	4,030	4,270	-	-	-	-	36,310	36,310
RECREATION LANDS:																		
Summer home tracts	-	-	-	140	-	-	7,770	4,850	-	110	-	670	-	-	-	-	13,540	13,540
Commercial	-	-	-	-	-	-	110	140	-	-	-	10	-	-	-	-	260	260
Campgrounds and trailer parks	-	-	-	80	-	40	1,410	80	-	200	-	430	-	-	-	-	2,240	2,240
SUBTOTALS	-	-	-	220	-	40	9,290	5,070	-	310	-	1,110	-	-	-	-	16,040	16,040
MAJOR PARKS																		
ALL OTHER LANDS	34,990	34,160	69,150	102,650	25,070	16,290	133,930	64,110	19,310	56,440	10,720	17,940	-	-	-	-	2,720	2,720
TOTALS	127,640	98,800	226,440	129,060	31,390	23,340	180,850	99,110	23,260	78,260	17,510	31,870	-	-	-	-	614,660	841,090

TABLE 16

PRESENT PATTERN OF LAND USE IN MAIN STREAM AND TRIBUTARY UNITS OF CALAVERAS AREA
(in acres)

Land Use	Main Stream		Total Main		Tributary Subunits										Total	
	Subunits		Stream	Bear	Jesus	Murphys	San	West	Tributary:	Point		Unit	Totals			
	Bachelor	Hogan	Unit	Mountain	Emery	Maria	Lodgepole	Angels	Nassau	Flat	Andreas	Point	Unit			
Irrigable Agricultural Lands																
Irrigated:																
Alfalfa	50	360	410	10	-	10	-	-	-	-	-	-	20	430		
Miso. Deciduous	260	2,430	2,690	-	30	-	-	10	-	-	-	30	260	2,950		
Misc. Field	300	1,000	1,300	-	-	-	-	-	-	-	-	-	-	1,300		
Grain	10	20	30	10	-	-	20	-	-	-	-	-	-	60		
Pasture	6,800	2,470	9,270	10	160	60	-	320	1,440	30	170	10	200	11,670		
Rice	440	-	440	-	-	-	-	-	-	-	-	-	-	440		
Subtropical	-	200	200	-	-	-	-	-	-	-	-	-	-	200		
Miso. Truck	40	500	540	-	-	-	-	-	-	-	-	-	-	540		
Vineyard	-	40	40	-	-	-	-	-	-	-	-	-	-	50		
Subtotals	7,900	7,020	14,920	30	190	60	340	1,650	30	180	10	230	2,720	17,640		
Non-Irrigated:																
Misc. Deciduous	220	220	220	-	90	20	20	80	-	30	-	230	470	690		
Grain	6,450	5,200	11,650	-	200	30	-	40	-	120	30	-	440	12,090		
Meadow Pasture	180	-	180	-	-	-	200	30	-	-	-	-	230	410		
Subtropical	-	100	100	-	10	-	-	-	-	-	-	-	10	110		
Vineyard	-	350	350	-	-	-	-	-	-	10	-	-	10	360		
Subtotals	6,630	5,870	12,500	210	110	50	220	150	-	160	30	230	1,160	13,660		
Urban and Suburban:	50	240	290	100	20	-	-	1,240	-	320	460	160	2,300	2,590		
Recreational Lands:																
Summer Homes	-	-	-	-	-	-	200	40	-	-	-	-	240	240		
Commercial	-	-	-	-	-	-	10	10	-	-	-	-	20	20		
Campgrounds	-	-	-	-	-	-	170	40	-	-	-	-	210	210		
Subtotals	-	-	-	-	-	-	380	90	-	-	-	-	470	470		
Major Parks	-	30	30	10	10	-	2,660	90	-	-	-	-	2,770	2,800		
All other lands	113,060	85,640	198,700	128,710	31,060	23,230	177,250	95,890	23,230	77,600	17,010	31,250	605,230	803,930		
Totals	127,640	98,800	226,440	129,060	31,390	23,340	180,850	99,110	23,260	78,260	17,510	31,870	614,650	841,090		

Table 17

PROJECTED PATTERN OF LAND USE IN MAIN STREAM AND TRIBUTARY UNITS FOR YEAR 2020
(in acres)

Land Use	Main Stream		Total Main		Tributary subunits					Total	
	Subunits	Backwater	Stream	Unit	Beaver	Jesus	Martha	Shodges	Angels	San	Tributary
					Mountains	Emery	Martha	Shodges	Angels	Point	Unit
<u>Irrigable Agricultural Lands: 1/</u>											
Alfalfa	950	1,040	1,990		190			190	190		570
Miso. Deciduous	4,050	6,750	10,800		570		480	380	1,140	40	7,830
Miso. Field Crops	3,250	2,000	5,250		100						100
Pasture	36,500	15,300	51,800		600	570	800	700	1,800	500	9,010
Subtropicals		500	500		190	670					190
Miso. Truck Crops	1,800	760	2,560		290				190		670
Vineyard	270	900	1,170		100				190	100	490
Double Cropped	2,120	1,230	3,350								
Subtotals	48,940	28,480	77,420		2,040	1,240	1,280	1,270	3,420	640	18,860
								380	5,830		96,280
<u>Irrigable Forestry and Range Lands</u>											
	-	-	-	-	-	-	-	30,540	1,980	-	36,310
<u>Urban and Suburban:</u>											
	50	550	600		580	630	210	40	11,210	4,030	25,890
<u>Recreational Lands:</u>											
Summer Homes	-	-	-		140	-	-	7,770	4,850	-	13,540
Commercial	-	-	-		-	-	-	110	140	-	260
Campgrounds	-	-	-		80	-	40	1,410	80	-	2,240
Subtotals	-	-	-		220	-	40	9,290	5,070	310	16,040
<u>Major Parks</u>											
	-	-	-		-	10	-	2,640	70	-	2,720
All Other Lands	78,650	69,770	148,420		126,220	29,510	21,810	137,070	77,360	22,880	515,430
Totals	127,640	98,800	226,440		129,060	31,390	23,340	180,850	99,110	23,260	614,650
								78,260	17,510	31,870	841,090

1/ The projected patterns of irrigated agricultural land use shown in this section are based on the assumption that water could be delivered to the farm headgates at a cost of \$5-10 per acre-foot. See footnote of Table 23.

Irrigable Agricultural Lands. These lands were classified according the slope and soil characteristics. Both slope and related soil factors directly affect the degree of suitability of the lands for irrigation and were the primary consideration in establishing the, "land class," i.e., the maximum potential use of the land. In predicting the future land use--particularly in the case of irrigable agricultural lands--the foregoing factors were considered but were modified by additional analysis of economic factors related to crop production and the locations of the land with respect to the water supply.

Topographic characteristics of irrigable agricultural lands are identified in the tables of this bulletin by the following symbols:

- V - These lands are level or slightly sloping and vary from smooth to hummocky or gently undulating relief. The maximum allowable slope is six percent for smooth, reasonably large-sized bodies lying in the same plane. As the relief increases and becomes more complex, lesser slopes are allowed. These lands are suitable for all climatically adapted crops.
- H - These are lands with greater slope and/or relief than those of the V class. They vary from smooth to moderately rolling or undulating relief. The maximum allowable slope is 20 percent for smooth, reasonably large-sized bodies lying in the same plane. As the relief increases and becomes more complex, lesser slopes are allowed.

M - These are lands with greater slope and/or relief than those of the H class. They vary from smooth to steeply rolling or undulating relief. The maximum allowable slope is 30 percent for smooth, reasonably large-sized bodies lying in the same plane. As the relief increases and becomes more complex, lesser slopes are allowed.

Irrigable agricultural lands identified as V, H, or M contain permeable soils with medium to deep effective root zones. They are free of rock and not limited by a high water table. Variations from this pattern are identified in the tables of this bulletin by the following sub-symbols:

- p - Shallow depth of effective root zone; land limited to shallow rooted crops.
- r - Sufficient rock to prevent crop cultivation.
- w - High water table; land limited to pasture crops unless drainage and a change in irrigation practice increase its adaptability to other types of crops.

Even in the most intensively developed areas of irrigated agriculture, not all areas classified as irrigable agricultural lands would receive water every year. The gross irrigable areas were therefore reduced for the following reasons:

1. Farmers would limit production on lands having limited adaptability and productivity to periods when economic conditions were favorable.

2. Crop rotation and fallowing would reduce the extent of irrigated land.

3. Farmsteads, industries, and rights-of-way such as roads, railroads, and canals would occupy acreage.

4. Certain nonirrigable lands occur within lands classified as irrigable because the area involved was too small to delineate.

5. Small, irregularly shaped plots of land, isolated by ownership or location from larger units of irrigable land, would be irrigated less readily than the larger units.

Estimates indicate that in the Main Stream and Tributary Units about 40 percent, or 96,300 acres, of the gross irrigable agricultural lands would be devoted to agricultural uses by the year 2020. For the above reasons, it is doubtful if this use will ever closely approach 100 percent.

Irrigable Forest and Range Lands

These lands are presently forested or subjected to forest or range management. They possess the slope and soil characteristics of irrigable agricultural lands but, because of conditions of climate and location, are best suited to remain under some type of forest or range management program. The tables of this bulletin identify irrigable forest and range lands with the symbol "F".

Urban and Suburban Lands

These lands may be irrigable or nonirrigable. Irrigable lands classified as potential urban and suburban

lands possess the characteristics of irrigable agricultural lands (V, H, or M) but most likely will be used to absorb urban and suburban expansion brought about by the anticipated increase in California population. Estimates of population in the Main Stream and Tributary Units in the year 2020 (Table 14) were used to help determine the amount of land classified as potential urban and suburban land. The tables of this bulletin identify urban and suburban lands by the following symbols:

UD - Urban (city, town, small community) lands; presently developed for commerce, industry, and residences.

U - Potential urban (city, town, small community) lands; probable intense future development for commerce, industry, and residences.

SR - Suburban and potential suburban lands; low density of residences; little or no commerce or industry.

The main purpose in the determination of U and SR lands was to indicate those irrigable lands of the area which urban encroachment would render unavailable for agriculture by the year 2020. Computation of water use in U and SR lands by the year 2020 is based on predicted population rather than on area.

Recreation Lands

These consist of lands presently or potentially characterized by fairly intensive recreation development

requiring water service. The classification does not include those high mountainous lands intensively used for recreation purposes by hunters and fishermen. Estimates of future population expansion (Table 14) and recognition of the increasing demand for recreation areas helped determine the acreage classified as potential recreation land. Estimates indicate that land so classified will be developed to its full potential by the year 2020. Computation of water use in recreation lands is based on predicted population rather than on area. Types of recreation lands are identified in the tables of this bulletin by the following symbols:

RR - Existing and potential permanent
and summer home tracts.

RC - Existing and potential commercial
areas (motels, resorts, hotels,
stores, etc.)

RT - Existing and potential camp and
trailer sites.

RR lands subdivide according to their probable density of development; fewer houses per acre; for example, will be built on hilly land than on flat land. Calculations of the density of development of RR, RC, and RT lands provided a basis for predicting water use and requirements by the year 2020.

Major Park Lands

These lands use little water and consist of existing county, state, and federal parks, race tracks, and

fairgrounds. The tables of this bulletin identify major park lands with the symbol "PP".

All Other Lands

These are identified in the tables of this bulletin by the symbol "N". The classification consists of all lands not included in one of the five previous designations. Table 15 shows all 6 designations and lists by units the acreage within each classification in the Main Stream and Tributary Units.

General Considerations Regarding Land Use

The development of a staged land-use pattern is contingent upon many factors, including:

1. The quantity and cost of water that can be made available during the projected period.
2. The quantity, contiguity, and productive ability of available lands susceptible to irrigation.
3. Estimates of demand for, and net revenues from, crops grown on project lands.
4. Estimates of the amount of lands to be utilized for summer homes and for urban, recreational, and industrial developments.
5. Forecasts of future transportation facilities affecting increases in population of nearby large urban centers.

Preliminary operation studies and cost estimates of potential projects indicate that some 30,000 acre-feet of water annually could be developed for use in the Tributary Unit.

In the Main Stream Unit, no limits were placed on the water that could be developed in projections of future land use. However, only those lands with payment capacities of from \$5 to \$10 per acre-foot were considered as likely to be developed by the year 2020.

Most of the irrigable lands in the Valley Unit are already under irrigation. Moreover, adequate and cheap water supplies for lands not now being irrigated will be obtainable in the future from the proposed Folsom South Canal. For this reason, the survey that was conducted on lands within the Valley Unit is not included in this report.

Present Land Use

Patterns of land use that existed during 1958 and 1959 were determined from field surveys during the current investigation. Data obtained during these field surveys are considered to be representative of present conditions of land use. A summary of the results of these surveys in the Tributary and Main Stream Units, and their subunits, is presented in Table 16. Present land use is pictorially presented on Plate 6, "Classification of Present and Potential Land Use."

It will be noted that the predominate present use of lands requiring water service is for irrigated agriculture. However, in the higher elevations of the area of investigation the use of land for urban, suburban, and

recreational purposes is proportionately much higher than in the lowlands. It is expected that this pattern of land use will continue in the future.

Projected Patterns of Land Use

An estimate of the potential land use pattern was prepared during the current investigation to aid in estimating probable water requirements for the year 2020. It is possible that, beyond this date, additional agricultural lands will require water service to meet the ultimate projected needs of the State. In view of the inherent uncertainties of predicting the pattern of future development, projections of land use were limited to the period ending at the year 2020.

Present Water Use

Of the presently developed waters utilized in the Tributary and Main Stream Units of the Calaveras area, only 63,500 acre-feet per year are consumptively used. It is estimated that the consumptive requirements of water for these units will approach 300,000 acre-feet annually by the year 2020. Of this future requirement, about 260,000 acre-feet annually must be developed by new projects; the apparent loss of 23,500 acre-feet per year is attributable to increased evaporation from the new projects. In addition,

there will be increased nonconsumptive requirements for fish and wildlife enhancement and hydroelectric generation.

Present Water Supply Development

Although there has been extensive development of the waters within the area of investigation, there remains substantial amounts of unregulated water that could be developed for beneficial use. There has been no significant development of water in the area for several decades. On the valley floor, ground water is the principal source of supply utilized in the production of irrigated crops and for industrial and urban uses. The foothill and highland areas obtain their water supplies mainly by direct diversion of unregulated water below hydroelectric projects. The use of ground water in these latter areas is extremely limited. The existing water supply developments within the Calaveras area are shown on Plate 7, "General Plan of Existing and Proposed Water Supply Development."

Mokelumne River Basin. The Mokelumne River has been extensively developed by several agencies, primarily for the generation of hydroelectric energy. Most of the water thus developed is exported to areas outside the scope of this investigation; a small portion of this water is used for local irrigation. The Pacific Gas and Electric Company operates a complex hydroelectric system on the North Fork Mokelumne River consisting of seven reservoirs

totaling 214,000 acre-feet of storage, and four powerplants having a combined installed capacity of 219,000 kilowatt. Water is regulated in Twin Lakes, Upper and Lower Blue Lakes, Meadow Lake, Upper and Lower Bear Reservoirs, and Salt Springs Reservoir. Releases are made from Lower Bear and Salt Springs Reservoirs, through separate units of Salt Springs Powerplant. From this powerplant, the regulated water is discharged through Tiger Creek and West Point Powerplants located on the North Fork, and Electra Powerplant located on the main stem of the Mokelumne River.

The Amador Canal diverts water from Lake Tabeaud, the forebay for Electra Powerplant, for domestic and irrigation use in Amador County. For the period 1925-26 through 1951-52, the maximum annual diversion through the Amador Canal was 10,700 acre-feet in 1936-37; the minimum was 5,600 acre-feet in 1951-52. Water rights pertaining to the Amador Canal, based upon use prior to the date of the Water Commission Act and subsequent adjudications, provide for an annual diversion of 15,000 acre-feet at a rate not to exceed 30 second-feet.

The Calaveras County Water District owns and operates a small reservoir on Bear Creek, a tributary to the Middle Fork Mokelumne River. Water released from this reservoir is diverted downstream and conveyed by pipeline to a second small reservoir near West Point. Here the

water is treated and distributed to 136 domestic users. The annual yield of this system is about 340 acre-feet.

The Calaveras Public Utility District operates a water distribution system that supplies water to domestic and industrial users in and near the towns of Wilseyville, Mokelumne Hill, and San Andreas. This system consists of Schaad Reservoir with a capacity of 1,700 acre-feet on the Middle Fork Mokelumne River and the necessary ditch systems for distribution of water to some 800 users. The water rights to this diversion amount to 12.5 second-feet for a total of 9,000 acre-feet annually with a maximum permissible diversion rate of 15 second-feet. The actual amount of diversion amounts to 4,500 to 7,500 acre-feet of which not more than some 3,500 acre-feet reaches the users due to the poor efficiency of the distribution system.

The East Bay Municipal Utility District owns and operates Pardee Reservoir on the main stem of the Mokelumne River. Pardee Reservoir has a storage capacity of 210,000 acre-feet and supplies water to satisfy downstream riparian rights, to users served by the Woodbridge Irrigation District, to export water for use within the East Bay Municipal Utility District, and for the production of hydroelectric energy in Pardee Powerplant. The district is constructing Camanche Dam on the Mokelumne River downstream from Pardee Dam. This dam will create a reservoir of 355,000 acre-foot capacity for the purpose of flood control and to provide



Pardee Dam and Powerplant on Mokelumne River

the district with its full annual entitlement of 364,000 acre-feet of water from the Mokelumne River.

The Woodbridge Irrigation District diverts water from the Mokelumne River at Woodbridge Dam, located adjacent to the town of Woodbridge. The diversion system consists of about 70 miles of canal that deliver water to about 14,200 acres within the district and about 21,200 acres without. For the 7-year period 1952 through 1959, the average annual diversion by the district was about 122,000 acre-feet.

Calaveras River Basin. The present development of the Upper Calaveras River Basin is limited to minor storage facilities and diversions. The Calaveras Public Utility District owns and operates a reservoir of 775 acre-foot capacity on the North Fork Calaveras River near Railroad Flat. Water from this reservoir is used to irrigate about 80 acres downstream from the dam.

Two small direct diversions of unregulated stream-flow are made from San Antonio Creek, the major tributary of the Calaveras River. The Calaveras County Water District operates a small diversion works located about 4 miles east of Sheep Ranch to divert water, through a poorly maintained ditch, to 33 users in the vicinity of Sheep Ranch. Downstream from the Sheep Ranch Diversion, the California Youth Authority diverts water for use at the Fricot Ranch School.



The U.S. Corps of Engineers is currently constructing New Hogen Dam on the main stem of the Calaveras River

Water is conveyed by pipeline which has a capacity of 205 gallons per minute. During the dry periods of some years, the runoff of San Antonio Creek is insufficient to meet the requirements of these two diversions. Other developments in the Upper Calaveras River Basin consist of minor direct diversions and/or farm ponds having negligible yield.

The U.S. Army Corps of Engineers is currently enlarging the capacity of Hogan Reservoir on the main stem of the Calaveras River. New Hogan Reservoir will have a capacity of 325,000 acre-feet and will be operated primarily to provide flood control for the Calaveras River and to supply a new yield of about 38,000 acre-feet annually.

Stanislaus River Basin. The waters of the Stanislaus River Basin have been extensively developed by the Pacific Gas and Electric Company and the Oakdale-South San Joaquin Irrigation Districts.

The Utica system is operated by the Pacific Gas and Electric Company on the North Fork Stanislaus River, which comprises Spicers Meadow Reservoir on Highland Creek, Alpine Reservoir on Silver Creek, Union and Utica Reservoirs on the Upper North Fork, and the Utica Ditch Diversion on the North Fork near Avery. Utica Ditch has a capacity of 88 second-feet, sufficient to supply 64,000 acre-feet per year to Hunter Reservoir. The ditch conveys water to Hunter Reservoir on Mill Creek where the water is regulated

and thence conveyed by ditch and flume to Murphys Forebay near the town of Murphys for subsequent discharge through Murphys Powerplant. Hunter Reservoir has a capacity of 200 acre-feet and Murphys Powerplant has an installed capacity of 3,600 kw. The Calaveras County Water District diverts water from Hunter Reservoir to supply some 70 users in Hathaway Pines. A portion of the Utica Ditch Diversion bypasses Murphys Forebay and spills into Taylor Creek, where it is diverted by the Calaveras Water Users Association for use in the town of Murphys.

After passing through Murphys Powerplant, the water is reregulated in a small afterbay, from which about 2,000 acre-feet annually is diverted by the Calaveras Water Users Association to about 500 users. The remaining supply is released to Angels Creek for diversion downstream through an extension of the Utica Ditch. This diversion amounts to about 1,800 acre-feet annually and is utilized for the irrigation of lands within the Angels Water Users Association. The remainder of the flow is transported to Angels Forebay where it is again regulated. From this point, a portion of the water is distributed among some 620 users in the towns of Angels Camp and Altaville, the remainder passing through Angels Powerplant on Angels Creek which has an installed capacity of 1,400 kw.

The discharge from Angels Powerplant is released to Angels Creek where it becomes available for diversion to the area below Angels Camp and above Melones Reservoir. Two ditches serve irrigated lands in this vicinity. All unused water is returned from the Utica system to the Stanislaus River above Melones Reservoir.

The waters of the Middle Fork Stanislaus River are the most completely regulated in the Stanislaus River Basin. Relief Reservoir on Relief Creek, with a storage capacity of over 15,000 acre-feet, was initially operated to supply water to Stanislaus Powerplant through a gross head of about 1,500 feet. Additional reservoirs have been constructed on the Middle Fork Stanislaus River in recent years, and water from Relief Reservoir now passes through the entire system of development.

Oakdale and South San Joaquin Irrigation Districts have constructed Donnell's and Beardsley Reservoirs on the Middle Fork Stanislaus River with storage capacities of 64,500 and 97,500 acre-feet, respectively. These reservoirs are operated by the two irrigation districts to increase the dependability of their water supplies from the Stanislaus River Basin. Water released from Donnell's Reservoir is routed through a tunnel to Donnell's Powerplant, located at the upper end of Beardsley Reservoir. Donnell's Powerplant has an installed capacity of 54,000 kw. Water

from Beardsley Reservoir is passed through Beardsley Powerplant, located at the toe of the dam. The powerplant has an installed capacity of 10,000 kw. The water from Beardsley Powerplant is reregulated in Beardsley Afterbay and then released downstream to Sand Bar Flat Diversion where the water is conveyed to Stanislaus Powerplant. Between Beardsley Afterbay and the Sand Bar Flat Diversion, the flow of the Middle Fork Stanislaus River is augmented by an import from the South Fork Stanislaus River through the Philadelphia Ditch which supplies the Spring Gap Powerplant. Because of the increased regulation of the Middle Fork Stanislaus River afforded by Beardsley and Donnell's Reservoir, the installed capacity of the Stanislaus Powerplant is being increased to 82,000 kw.

The Pacific Gas and Electric Company operates two hydroelectric power systems on the South Fork Stanislaus River. The upper system begins at Strawberry Reservoir, with a capacity of 18,600 acre-feet. Regulated water is released to the South Fork Stanislaus River and is diverted through the aforementioned Philadelphia Ditch and Spring Gap Powerplant on the Middle Fork Stanislaus River. This powerplant has an installed capacity of 6,000 kw. For the period of October 1939 through September 1958, the average annual diversion through the Philadelphia Ditch was 31,500 acre-feet.

The lower system consists of Lyons Reservoir, the Tuolumne Ditch, Phoenix Powerplant, and Phoenix Reservoir. Lyons Reservoir has a storage capacity of 5,500 acre-feet. Water is conveyed from this reservoir via the Tuolumne Ditch to the Phoenix Powerplant, which has an installed capacity of 1,600 kw. Enroute, diversions are made from the Tuolumne Ditch to serve the water needs of the Twain Harte, Tuolumne, and Columbia areas. The water discharged through Phoenix Powerplant is re-regulated in Phoenix Reservoir on Sullivan Creek, a tributary of the Tuolumne River. This reservoir has a capacity of 850 acre-feet and is the principal source of water supply for Tuolumne County Water District No. 2. The water is used for irrigation and domestic purposes in the Standard, Sonora, and Jamestown areas. For the period of October 1937 through September 1958, the average annual diversion from Lyons Reservoir was 17,500 acre-feet.

Conservation and diversion works on the main stem of the Stanislaus River are owned and operated by the Oakdale and South San Joaquin Irrigation Districts. The works include Melones, Tulloch, and Goodwin Reservoirs, and two large capacity canals serving the districts both north and south of the Stanislaus River. Melones Reservoir, with a storage capacity of 112,000 acre-feet, is the principal storage facility. Water released from Melones Reservoir



Tulloch Reservoir on the Stanislaus River is owned and operated by the Oakdale and South San Joaquin Irrigation Districts

passes through the Pacific Gas and Electric Company's Melones Powerplant, with an installed capacity of 23,400 kw. The water is then reregulated in Tulloch Reservoir, which has a storage capacity of 68,000 acre-feet. Releases from Tulloch Reservoir pass through a powerplant owned by the irrigation districts. The powerplant has an installed capacity of 17,000 kw. This water is, in turn, reregulated in Goodwin Reservoir for subsequent discharge into the aforementioned irrigation canals.

Foothill Streams. Several small stream basins located in the foothills of the area of investigation contain water storage facilities that are of importance. The major foothill stream is Littlejohns Creek, which drains a major portion of the foothill and valley floor areas between the Calaveras and Stanislaus Rivers. The major developments on this creek include Woodward Reservoir on the Simmons Creek Tributary, Salt Springs Reservoir on the Rock Creek Tributary, and Farmington Reservoir on lower Littlejohns Creek. These three reservoirs impound a total of nearly 100,000 acre-feet for the purpose of augmenting irrigation supplies and in the case of Farmington Reservoir for flood protection.

There are also numerous farm ponds located on the various foothill streams that provide rather insignificant amounts of water for local use.

Water Requirements

Estimates of the water deliveries required for consumptive use on agricultural lands have been prepared by applying unit values of water use to the land use areas previously discussed. Estimates of water requirements for other uses, discussed in subsequent sections, were based on per capita demands and population forecasts.

Unit Use of Water

Unit values of water use were determined for each of the major types of land use in the area of investigation. These were based on unit values in other areas, adjusted for conditions in the Calaveras area.

Irrigation Water. Average annual unit values of consumptive use of applied water for irrigated crops in the area of investigation were determined by an empirical method which makes use of measured amounts of consumptive use and climatological factors. The derived unit values of consumptive use would occur under average conditions of climate and an adequate water supply available to produce optimum crop yields.

The efficiency of application of irrigation water is the ratio of the quantity of water consumptively used to the amount of water required at the farm headgate. Estimates of probable efficiency must take into account soil characteristics, terrain, types of crops irrigated, present

irrigation practices, and probable future irrigation practices. Estimates of irrigation efficiency for large areas are, of necessity, very general and represent the efficiency resulting from many individuals irrigating various crops on different types of land.

The estimated annual unit consumptive use of applied water, the estimated average farm irrigation efficiency, and the resulting unit farm water delivery requirements are shown in Table 18.

Population in Year 2020. Estimates of water use for urban, suburban, and recreational purposes were based on estimates of permanent population in the year 2020. The estimated populations of the Main Stream and Tributary Units of the Calaveras area in the year 2020 are shown in Table 14. These projections were based upon estimates by the Department of Water Resources for the counties involved. Population estimates for various subunits were made in accordance with existing and projected developments, with special consideration given to the probability of further industrial developments, oriented to mineral resources, in the San Andreas, Murphys-Angels, Bear Mountain, and Hogan Service Areas. Further developments in lumbering and wood processing are expected in the West Point vicinity, and to a lesser extent elsewhere, drawing on the commercial stands of timber found at higher elevations. Also, small

TABLE 18

ESTIMATED CONSUMPTIVE USE, EFFICIENCIES, AND UNIT REQUIREMENTS OF
IRRIGATION WATER IN THE MAIN STREAM AND TRIBUTARY UNITS

Crop	: Unit seasonal : Irrigation efficiency, : Unit irrigation requirement,											
	: consumptive use :			: in percent :			: in acre-feet per acre					
	: of applied water, :			: by land class ^{1/} :			: by land class ^{1/}					
	: in acre-feet/acre : Present : A : B : C : D : A : B : C : D : Weighted average											
Alfalfa	2.4	75	80	70	75	-	3.0	3.4	3.2	-	-	3.0
Deciduous	1.5	75	80	70	75	80	1.9	2.1	2.0	1.9	-	1.0
Miscellaneous field	0.9	70	75	65	70	-	1.2	1.4	1.3	-	-	1.2
Pasture	2.5	70	75	65	70	75	3.3	3.8	3.6	3.3	-	3.5
Rice	4.1	65	60	-	70	-	6.8	-	5.8	-	-	5.8
Subtropical	1.5	75	80	70	75	80	1.9	2.1	2.0	1.9	-	2.0
Truck crops	0.9	70	75	70	70	-	1.2	1.3	1.2	-	-	1.3
Vineyard	1.2	75	80	70	75	80	1.5	1.7	1.6	1.5	-	1.5
Double cropped ^{2/}	-	-	-	-	-	-	-	-	-	-	-	2.4

1/ Letters refer to the following land class groupings:

- A - V, Vw
- B - VL
- C - VP, VH
- D - VR, V PR, H, HR, HP, HPR, M, MP, MR, and MPR.

2/ Water requirement for the second crop.

homesite developments and recreation-oriented services and facilities are expected to continue to increase in the eastern half of Calaveras County. The rural population estimate is based upon expected agricultural developments, as well as an expected increase in rural, nonfarm residences.

Urban and Suburban, Recreation, and Rural Domestic Water Use. Estimates of unit values of water use for urban, suburban, recreational, and rural domestic purposes were determined on a per capita basis. Estimates of unit consumptive use of water for population categories were made from studies of water deliveries to communities in the Calaveras area and from studies of other representative communities in the mountain and foothill areas of the Sierra Nevada. These studies indicate that the average rate of water deliveries to these communities is about 200 gallons per capita per day. From the same data, it was estimated that the present average rate of consumptive use is about 100 gallons per capita per day.

The average rate of water use per capita for various types of urban development has been increasing for the past several decades and is expected to continue to increase in the future. However, past rates of increase do not form a completely satisfactory base from which to project the level of future use. From prior studies of water use trends, it was estimated that the urban and

suburban unit requirement for water in upland communities would increase to about 250 gallons per capita per day by the year 2020. It was further estimated that rural domestic use of water will not change within the near future.

For the purposes of this investigation, it was assumed that water requirements for all recreational use, where population concentrations exceed 1.8 persons per acre, would be supplied as part of the urban requirement. For rural domestic population densities of less than 1.8 persons per acre, it was assumed that water requirements would be contained in the irrigation supply. This assumption was made on the premise that home sites in less densely populated areas would probably occupy lands classified as irrigable.

Consumptive Use of Applied Water

Estimates were made of consumptive use of applied water under present and year 2020 conditions of development. These estimates were based upon the previously presented estimates of unit values of consumptive use of applied water, present and future patterns of land use, and present and future population.

Present Consumptive Use of Applied Water. The amount of applied water consumptively used on presently irrigated lands was taken to be the product of the acreage devoted to each irrigated crop and its estimated mean unit

value of consumptive use. It was assumed that all crops are presently receiving a full water supply so that sufficient moisture is available in the root zone to maintain active plant growth.

The amount of consumptive use of applied water in urban, suburban, and recreational areas was estimated as the product of population for each category and the appropriate value of per capita consumptive use of water. Estimates of consumptive use of water for urban and suburban categories include an allowance for industrial purposes.

Estimates of present mean annual consumptive use of applied water in the Main Streams and Tributary Units are presented in Table 19.

Year 2020 Consumptive Use of Applied Water. Year 2020 annual consumptive use of applied water by agricultural, urban, suburban, rural, and recreational areas was estimated as the product of the forecast level of development and appropriate unit value of consumptive use of water. The methods and assumptions used were the same as those employed to estimate present consumptive use of applied water. The estimated values of consumptive use of applied water under year 2020 conditions are presented in Table 20.

Irrigation Efficiencies. Water requirements depend, to a large extent, upon the efficiency with which

TABLE 19

ESTIMATED PRESENT MEAN ANNUAL AGRICULTURAL CONSUMPTIVE USE OF APPLIED WATER IN THE
MAIN STREAM AND TRIBUTARY UNITS
(In acre-feet)

Land use	Main Stream		Total Main		Tributary Subunits							Total	
	Subunits	Bear	Stream	Jesus	Murphy	San	West	Tributary	Point	Subunits	Totals	Subunits	Totals
	Hogan	Mountain	Enery	Marina	Lodgepole	Angels	Nassau	Flat	Andreas				
IRRIGATED AGRICULTURE:													
Alfalfa	120	860	980	20	-	20	-	-	-	-	40	1,020	
Miscellaneous deciduous	390	3,640	4,030	-	50	10	270	-	20	0	50	400	4,430
Miscellaneous field	270	900	1,170	-	-	-	-	-	-	-	-	-	1,170
Pasture	17,000	6,180	23,180	30	400	150	800	70	430	20	500	6,000	29,180
Rice	1,800	-	1,800	-	-	-	-	-	-	-	-	-	1,800
Subtropicals	-	300	300	-	-	-	-	-	-	-	-	-	300
Miscellaneous truck	40	450	490	-	-	-	-	-	-	-	-	-	490
Vineyard	0	50	50	-	-	-	10	-	-	-	-	10	60
Double cropped	10	50	60	20	-	-	50	-	-	-	-	70	130
TOTALS	19,630	12,430	32,060	70	450	150	830	70	450	20	550	6,520	38,580

TABLE 20

ESTIMATED MEAN ANNUAL AGRICULTURAL CONSUMPTIVE USE OF APPLIED WATER 1/
FOR YEAR 2020 IN THE MAIN STREAM AND TRIBUTARY UNITS
(In acre-feet)

Land use	Main Stream		Total Main:		Tributary Subunits						Total :	
	Subunits		Stream	Bear	Jesus:	Murphys:	Angels:	Lodgepole:	Nassau:	Flat	West :	Tributary :
	Bachelor:	Hogan	Subunits	Mountain	Emery:	Marie:	Lodgepole:	Angels:	Nassau:	Flat	Andrea:	Point: Subunits :
IRRIGATED AGRICULTURE:												
Alfalfa	2,280	2,500	4,780	460	-	-	460	460	-	-	-	1,380
Miscellaneous deciduous	6,080	10,120	16,200	860	860	720	570	1,710	150	4,280	60	2,550
Miscellaneous field	2,920	1,800	4,720	90	-	-	-	-	-	-	-	90
Pasture	91,250	38,250	129,500	1,500	1,670	2,000	1,750	4,500	700	6,500	1,250	2,650
Subtropicals	-	750	750	280	-	-	-	-	-	-	-	280
Miscellaneous truck	1,620	680	2,300	260	-	-	-	170	-	170	-	600
Vineyard	320	1,080	1,400	120	-	-	-	120	-	230	120	590
Double cropped	5,090	2,950	8,040	-	-	-	-	-	-	-	-	-
TOTALS	109,560	58,130	167,690	3,570	2,530	2,720	2,780	6,960	850	11,180	1,430	5,200
												37,220
												204,910

1/ The estimated mean annual consumptive use of water shown in this table is based on the assumption that water could be delivered to the farm headgates at a cost of \$5-10 per acre-foot. See footnote of Table 23.

delivered water is utilized. Irrigation efficiencies are, therefore, used to convert consumptive water requirements to delivery requirements. The irrigation efficiencies used in determining farm delivery requirements are presented in Table 18. Total requirements for domestic uses of water were computed using an efficiency of 50 percent.

Monthly Demands for Water. Since irrigation demands fluctuate widely from month to month, the capacity of the distribution system must be sufficient to meet the peak demand. Irrigation demands occur primarily in the summer, from May through October. The maximum demand for water in the Calaveras area occurs during July.

The demand pattern for domestic water is nearly continuous throughout the year with increases during the summer months for the watering of lawns and gardens. Recreational demands also show increases during summer months. Monthly demands for water for the generation of hydroelectric energy have a pattern similar to that for combined irrigation and domestic requirements. Estimated monthly distribution of demands for water in the Calaveras area are presented in Table 21.

Permissible Deficiencies. Studies were not made during this investigation to determine deficiencies in the supply of irrigation water that might be endured without permanent injury to perennial crops. It has been determined

TABLE 21

ESTIMATED AVERAGE MONTHLY DISTRIBUTION
OF DEMANDS FOR WATER
IN THE CALAVERAS AREA
(In percent of seasonal total)

Month	: Hydroelectric : energy generation	: Irrigated agricultural : and urban uses
January	6.1	2.0
February	5.3	1.0
March	6.8	1.0
April	7.6	3.0
May	8.0	12.0
June	10.3	16.0
July	13.0	20.0
August	13.0	19.0
September	9.1	15.0
October	7.5	7.0
November	6.5	2.0
December	<u>6.8</u>	<u>2.0</u>
TOTALS	100.0	100.0

in the past that in areas similar to the Calaveras area, crops can endure a 35 percent deficiency in the annual water requirements if such deficiency occurs only at relatively long intervals of time. It is assumed that a deficiency of 35 percent could be endured in one year of the 35 year operational period utilized in this investigation. However, since the irrigation demand for the Tributary Unit is less than 15 percent of the total demand, including hydroelectric requirements, no deficiency was taken in studies involving water diverted from the North Fork Stanislaus River.

Conveyance Losses. Conveyance losses result from seepage, leakage, evaporation, and transpiration of riparian vegetation. For the purposes of this investigation it was assumed that conveyance losses would approximate return flow from irrigated lands not accounted for in the determination of water requirements in irrigable areas. It will be seen that reuse of applied water will depend upon the contiguity of the irrigated lands within a service area and the facility with which this return flow may be directed to beneficial use. Generally, it was felt that the difference between the amount of applied water and the consumptive use of an area, less 10 percent consumption by weeds, would be available for reuse. This amount should be sufficient to allow for the expected losses in supply and distribution ditches.

Water Requirements

Water requirements were estimated for present conditions and for the year 2020. These estimates were assumed to be those amounts of water required at the farm headgate or the point of connection with a domestic delivery system.

Present Water Requirements. Estimates of the amount of water required on presently irrigated lands were derived by the product of the acreage devoted to each irrigated crop and its estimated unit delivery requirement.

Water requirements for urban, suburban, rural, and recreational uses were estimated as the product of the population count in each category and the corresponding unit values of water delivery requirements.

Estimates of present mean annual water requirements in the Main Stream and Tributary Units are presented in Table 22.

Year 2020 Water Requirements. Year 2020 water requirements for agricultural, urban, suburban, rural, and recreational areas were estimated as the product of the projected level of development and the corresponding unit value of water delivery requirement. The methods and assumptions utilized were the same as those employed to estimate present consumptive water requirements.

TABLE 22

ESTIMATED PRESENT MEAN ANNUAL WATER REQUIREMENTS IN THE
MAIN STREAM AND TRIBUTARY UNITS
(In acre-feet)

Land use	Main Stream		Total Main:		Tributary Subunits										Total :	
	Subunits		Stream :		Bear :		Jesus:		Murphys:		Railroad:		San :		Tributary:	
	Bachelor:	Hogan :	Subunits :	Mountain :	Emery:	Maries:	Lodgepole:	Angela:	Nassau:	Flat :	Andrea:	Point:	Subunits:	Totals		
IRRIGATED AGRICULTURE:																
Alfalfa	150	1,080	1,230	30	-	-	30	-	-	-	-	-	-	60	1,290	
Miscellaneous deciduous	500	4,620	6,120	-	60	-	20	340	-	20	-	60	500	5,620		
Miscellaneous field	360	1,220	1,580	-	-	-	-	-	-	-	-	-	-	-	1,580	
Pasture	23,800	8,640	32,440	40	560	210	1,120	5,040	100	600	40	700	8,410	40,850		
Subtropicals	-	400	400	-	-	-	-	-	-	-	-	-	-	-	400	
Rice	2,550	-	2,550	-	-	-	-	-	-	-	-	-	-	-	2,550	
Miscellaneous truck	50	650	700	-	-	-	-	-	-	-	-	-	-	-	700	
Vineyard	-	60	60	-	-	-	-	20	-	-	-	-	20	80		
SUBTOTALS	27,410	16,670	44,080	70	620	210	1,170	5,400	100	620	40	760	8,990	53,070		
URBAN AND SUBURBAN	20	20	40	70	20	0	40	740	10	310	290	360	1,840	1,880		
INDUSTRIAL	-	600	600	-	-	-	-	300	-	-	1,650	300	2,250	2,850		
TOTALS	27,430	17,290	44,720	140	640	210	1,210	6,440	110	930	1,980	1,420	13,080	57,800		

Estimates of annual water requirements for the year 2020 in the two units are presented in Table 23.

Nonconsumptive Water Requirements

Certain nonconsumptive requirements for water, such as those for hydroelectric power generation, conservation of fish and wildlife, and recreational pursuits, were considered to be significant in planning for the comprehensive development of water resources in the Calaveras area. In most instances, the magnitude and effect of nonconsumptive water requirements must be determined individually for each segment or unit of a project. Therefore, the following discussion of nonconsumptive water requirements is presented in general terms, and specific discussion of requirements is presented, where appropriate, in other portions of this bulletin.

Hydroelectric Power Generation. The principal nonconsumptive requirement for water within the area of investigation is for the production of hydroelectric energy. Although this requirement does not generally result in the consumption of water or in a depletion of water supply, it plays a substantial part in the regimen of stored water. Revenue from the sale of hydroelectric energy and power could reduce the cost of water to the various water users.

Recreation and Fish and Wildlife. By virtue of its climate and natural attractions, the Calaveras area

TABLE 23

ESTIMATED MEAN ANNUAL WATER REQUIREMENTS FOR THE YEAR 2020 IN THE MAIN STREAM AND TRIBUTARY UNITS 1/

(In acre-feet)

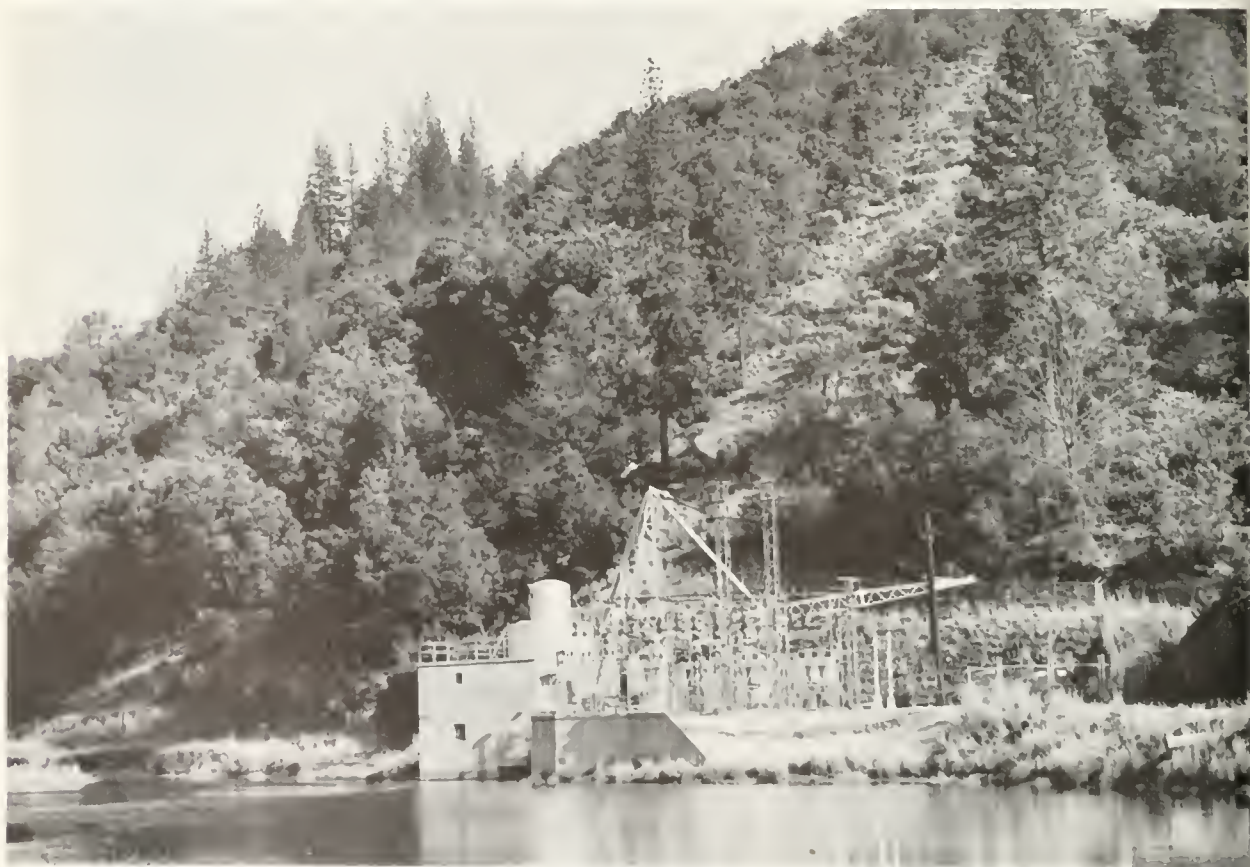
Land Use	Main Stream Subunits of Total Main				Tributary Subunits										Total	
	Bachelor	Mogans Subunits	Stream	Bear	Jeaus	Mountains	Emery	Marla	Lodgepole	Angels	Nassau	Flat	Railroad	San	West	Tributary
Irrigable Agricultural Lands:																
Alfalfa	2,850	3,120	5,970	570	-	570	1,080	910	720	2,170	190	5,420	-	80	3,230	1,710
Miso. Deciduous	7,700	12,820	20,520	1,080	-	720	1,080	910	720	2,170	190	5,420	-	80	3,230	14,880
Miso. Field	3,900	2,400	6,300	120	-	-	120	-	-	-	-	-	-	-	-	-120
Pasture	127,750	53,550	181,300	2,100	2,340	2,450	2,100	2,800	2,450	6,300	980	9,100	980	1,750	3,710	31,530
Subtropiceale	-	1,000	1,000	380	-	-	-	-	-	-	-	-	-	-	-	380
Miso. Truck	2,340	990	3,330	380	-	-	-	-	-	250	-	250	-	-	-	880
Vineyard	400	1,350	1,750	150	-	-	-	-	-	150	-	280	-	150	-	730
Double Cropped	5,090	2,250	8,040	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	150,030	78,180	228,210	4,780	3,420	3,740	4,780	3,710	3,740	9,440	1,170	15,050	1,980	6,940	50,230	278,440
Urban and Suburban	340	770	1,110	270	500	420	500	420	420	5,600	40	1,680	1,680	1,120	11,730	12,840
Industrial	400	2,100	2,500	450	-	-	-	-	-	1,000	-	850	3,700	600	6,600	9,100
Subtotal	740	2,870	3,610	720	500	420	500	420	420	6,600	40	2,530	5,380	1,720	18,330	21,940
Total Requirements	150,770	81,050	231,820	5,500	3,920	4,130	5,500	3,920	4,160	16,040	1,210	17,580	7,360	8,660	68,560	300,380
Nonproject Supply*	10,730	16,170	26,900	80	590	100	590	100	1,000	6,340	80	710	1,940	1,360	12,200	39,100
Project Water Required	140,040	64,880	204,920	5,420	3,330	4,030	5,420	3,330	3,160	9,700	1,130	16,870	5,420	7,300	56,360	261,280

* The nonproject supply is generally based on the present supply, which in turn is equivalent to present water requirements as shown in Table 22. The nonproject supply shown above is less than the present requirements in certain instances where the present supply is not considered to be firm.

1/ The estimate of water requirements shown in this table is based on the utilization of water that would result if it could be delivered to the user for a cost of \$5-10 per acre-foot. It should be noted that the predicted water requirements, particularly those for irrigated agriculture, would be substantially reduced if the cost of water, delivered at the farm headgates, would exceed the assumed cost.



Water for stock watering purposes and for the development of hydroelectric energy is essential to the economy of the area investigated



has outdoor recreational potentials of great importance to the local economy and of significant importance to the State as a whole. With anticipated continued growth in population and an increasing interest in recreation, it is expected that public demand for preservation and enhancement of recreational opportunities and of fish and wildlife will be of sufficient importance to warrant consideration in the planning of any water conservation project.

Boating, sailing, and swimming are generally incidental uses of water development for other purposes. However, in certain areas the recreation potential of a reservoir may be improved by slight modifications in the operation procedure without noticeably affecting the required yield therefrom. Insofar as possible, every consideration was given to the improvement of recreational potentials of reservoirs within the area of investigation.

The preservation and propagation of fish life is also of considerable importance to the economy of the Calaveras area. Water released from a reservoir for the preservation or enhancement of fish life does not constitute a consumptive use of water. These releases, however, are frequently incompatible with the demand for other beneficial uses. Nevertheless, it is important that existing fisheries be maintained and that certain fisheries be enhanced or created where none previously existed.

During the course of this investigation, the California Department of Fish and Game conducted studies of the fisheries along North Fork Stanislaus River, the results of which are presented in Appendix A. This appendix establishes recommended minimum flows for the North Fork Stanislaus River and discusses the enhancement which would result from greater flows. In planning for water development, the recommended maintenance flows were provided, insofar as practicable, in keeping with other beneficial requirements and financial feasibility.

Flood Control. Flood damage within the foothill and highlands portions of the Calaveras area in the past has been relatively light. Damages have usually been limited to roads, bridges, and minor erosion of agricultural lands. In preliminary planning of water conservation projects, flood control was, therefore, not considered. Flood protection to valley lands will be provided in the near future as a result of the construction of major storage reservoirs on the lower reaches of the Mokelumne, Calaveras, and Stanislaus Rivers.



Sailing on Pardee Reservoir

CHAPTER IV. WATER RIGHTS

Adequate appropriative water rights are a necessary prerequisite to the construction of any water development project, whether large or small, which involves a storage or direct diversion of surface water for use on nonriparian land. Prior to December 19, 1914, the effective date of the Water Commission Act, rights by appropriation could be initiated by the diversion and beneficial use of water and the priority could be preserved by recording a notice with the county recorder. Since that date, initiation of appropriative rights has been made by filing an application with the State Water Rights Board, or one of its predecessor agencies. If unappropriated water is available and other requirements are met, a permit is issued, and after the application of the water to the contemplated beneficial use is completed, the right is confirmed by a license. The priority of the right is the date on which the application was filed.

State Applications

The Legislature, during its 1927 session, enacted Chapter 286, which is now codified in Part 2 of Division 6

Code. Section 10500 of this part of the Water Code reads, in part, as follows:

"10500. The Department shall make and file applications for any water which in its judgment is or may be required in the development and completion of the whole or any part of a general or co-ordinated plan looking toward the development, utilization, or conservation of the water resources of the State...."

Under the authority vested in it by the preceding section, the State has filed water rights applications in furtherance of irrigation and domestic developments in the Mokelumne, Calaveras, and Stanislaus River Basins. Applications Nos. 5647, 5648, and 5649 were filed on July 30, 1927, Applications Nos. 13333 and 13334 were filed on September 6, 1949, and Applications Nos. 14858 and 14859 were filed on June 16, 1952.

Applications filed by the State may be: (1) assigned or (2) released from priority in favor of junior applications. Since 1959 this authority has been vested in the California Water Commission by Section 10504 of the Water Code. The commission is required to hold public hearings on requests for assignments or releases from priority of these applications as stated in Section 10504.1 of the Water Code. Any disposition of a state application by the commission is subject to review by the court. In the cases where state applications are involved, the California

Water Commission is required to approve the substance of these applications prior to their submission to the State Water Rights Board. After such approval by the commission, the board may then take further action toward approval of such applications by the issuance of a permit and subsequent license on these applications.

Requests for assignments or releases from priority of portions or all of State Applications Nos. 5647, 5648, 5649, 13333, 13334, and 14858 presently pending before the California Water Commission are as follows:

<u>Agency</u>	<u>: Applications</u>
Calaveras County Water District	5647, 5648, 13333, and 13334
Woodbridge Irrigation District	5648
Tuolumne County Water District No. 2	5648 and 5649
City of Oakdale	5648 and 5649
Pacific Gas and Electric Company	5649

County of Origin Law

Plans for taking large quantities of water from one area to another have resulted in fear on the part of the areas of surplus that there will not be adequate water remaining for their future needs. The County of Origin Law

was enacted in 1931 to afford protection to the counties wherein the water originates. It applies only to state applications filed under Section 10500. This law, now Section 10505 of the Water Code provides as follows:

"10505. No priority under this part shall be released nor assignment made of any application that will, in the judgment of the commission, deprive the county in which the water covered by the application originates of any such water necessary for the development of the county."

This protection has three principal limitations: first, it is only effective as to applications filed by the State pursuant to Section 10500 of the Water Code; second, it is dependent upon periodic relief by the Legislature from the usual requirements of diligence which apply to all other applications; and third, it applies only to water originating within a county.

The releases from priority and assignments executed since 1927 have usually contained a clause reserving either a specified amount of water for the county of origin or a general reservation without attempting to specify a definite quantity. Releases and assignments granted recently have, in nearly all cases, contained a general reservation of water for the future development of the counties of origin.

Existing Water Rights

Since the effective date of the Water Commission Act on December 19, 1914, many applications to appropriate waters of the Mokelumne, Calaveras, and Stanislaus Rivers have been filed with the State Water Rights Board or its predecessor agencies. This report will not attempt to list these applications nor will it present an accounting of the existing water rights on these rivers. However, a brief discussion of established rights, uses, or claims of the major water users, from the Mokelumne, Calaveras, and North Fork Stanislaus Rivers Basins will be set forth for each basin.

Mokelumne River Basin

Major appropriators of water from the Mokelumne River system above Woodbridge Dam under permitted and licensed water rights applications on record with the State Water Rights Board are the Pacific Gas and Electric Company, East Bay Municipal Utility District, North San Joaquin Water Conservation District, Woodbridge Irrigation District, Woodbridge Water Users Conservation District, County of Amador, and Jackson Valley Irrigation District. Pending applications include those of Calaveras County Water District proposing appropriations from the North, Middle, and South Forks of the Mokelumne River.

Calaveras River Basin

The Calaveras River Basin is not highly developed and therefore large amounts of water are not presently being appropriated under water right applications on file with the State Water Rights Board, appropriative rights initiated prior to 1914, or riparian rights. However, there are numerous applications on which permits or licenses have been issued within the Calaveras River Basin. The bulk of these applications name relatively small appropriations, primarily for irrigation and domestic uses.

Applications which propose the appropriation of the bulk of the water in the Calaveras River have not yet been approved by the State Water Rights Board. These include applications by the Calaveras County Water District, Stockton and East San Joaquin Water Conservation District, City of Stockton, and the United States of America. During April 1963, the board held hearings on these applications, and the board's decision is expected during the late summer of 1963.

Stanislaus River Basin

The appropriative rights to the use of water of the Stanislaus River system initiated prior to December 19, 1914, the effective date of the Water Commission Act, were determined by Decree No. 16873, entered on November 14, 1929,

by the Superior Court of San Joaquin County in the Stanislaus River Adjudication Proceeding. The decree was subsequently modified by orders or supplemental decrees entered on February 24, 1930, March 8, 1934, and May 8, 1935. As modified, the decree awarded water rights to the extent of 2,558.8 second-feet direct flow diversion and 45,925 acre-feet per annum storage, to 42 users. Of the amounts awarded, 2,525.3 second-feet, and the entire 45,925 acre-feet, were allocated to the Oakdale and South San Joaquin Irrigation Districts and the Pacific Gas and Electric Company or their predecessors in interest, which include the Tuolumne and Utica Ditch systems. The remaining 33.5 second-feet were allocated among 38 users.

Numerous appropriations from the Stanislaus River stream system have been initiated since 1914 by applications for permits and licenses under the provisions of the Water Code. A preponderance of these appropriations are for small amounts of water, while the bulk of the water appropriated or sought to be appropriated is confined to relatively few applications by the Oakdale and South San Joaquin Irrigation Districts and the Pacific Gas and Electric Company. In general, the permitted and licensed applications are to supplement use under the rights determined in the adjudication proceeding.

Additional applications have been filed with the board since 1947 as follows: Calaveras County Water District,

12 applications; Tuolumne County Water District No. 2, 7 applications; and Oakdale and South San Joaquin Irrigation Districts, 5 applications. Hearings were held by the board during 1962, and Decision D-1114 was adopted on March 14, 1963. All 12 of the applications made by the Calaveras County Water District were approved, two of those made by Tuolumne County Water District No. 2 were approved, and the remaining applications were denied.

Pacific Gas and Electric Company. Existing water rights of the company on the Stanislaus River can most readily be explained in connection with its five separate systems. These are: (1) the Utica Ditch system on the North Fork, (2) the Phoenix system on the South Fork, (3) the Spring Gap system on the Middle and South Forks, (4) the Stanislaus Tunnel and Powerplant on the Middle Fork and main stem of the Stanislaus, and (5) the Melones Powerplant below Melones Dam on the main stem. The Utica Ditch system is the only one of the five which is relevant to the Calaveras Investigation.

The Utica Ditch system consists of Alpine, Utica, and Union Reservoirs on the upper reaches of the North Fork, Spicer Meadow Reservoir on Highland Creek, the Utica Ditch, Utica (Murphys) Powerplant, and Angels Powerplant.

The Stanislaus River Decree sets forth rights to 88 second-feet direct flow of the North Fork and its

tributaries for diversion through the Utica Ditch, and 9,000 acre-feet per annum of storage in Alpine, Utica, and Union Reservoirs. In addition, Pacific Gas and Electric Company has a right to store water in Spicer Meadow Reservoir which has a storage capacity of 4,062 acre-feet. The Stanislaus River Decree provides that water stored in the above-named reservoirs is to be used in equalizing the flow of the North Fork at the intake of the Utica Ditch to a flow of 88 second-feet; 55 second-feet of the 88 second-feet direct flow or equalized flow diverted through the Utica Ditch are to be used for the generation of power at the Utica (Murphys) Powerplant; and that said 55 second-feet together with the remaining 33 second-feet diverted through the Utica Ditch, making a total of 88 second-feet, either before or after passing through Utica Powerplant, are to be used for public service purposes, including domestic, industrial, and irrigation uses. In addition, the decree (Paragraphs 52 through 58) provides for rights to 2.5 second-feet from Mill Creek, 56.7 second-feet from Angels Creek, and 8.0 second-feet from Coyote Creek for public service purposes.

Calaveras County Water District. Calaveras County Water District has 11 applications approved, as amended by Decision D-1114, for permits to appropriate water from the North Fork Stanislaus River watershed for irrigation,

municipal, industrial, domestic, stockwater, and power purposes. The agency has one additional application for water to be developed by storage on Black Creek, tributary to the main stem near the town of Copperopolis, which was also approved by Decision D-1114.

Summary

Conflicting water right applications were filed by Tuolumne County Water District No. 2, Calaveras County Water District, and Oakdale and South San Joaquin Irrigation Districts for use of waters on the North Fork of the Stanislaus River. Water right applications have been filed by the State of California pursuant to Section 10500 of the Water Code for water for future development on this stream. Hearings were conducted by the State Water Rights Board and Decision D-1114 was adopted, which approved all of the applications of Calaveras County Water District, approved two of the applications of Tuolumne County Water District No. 2, and denied all other applications. It may also be necessary at a later date for the California Water Commission to hold hearings on the state applications involved.

In order to determine the extent of availability of unappropriated water on the Mokelumne River, it appears that hearings will be required by the State Water Rights Board on applications of the Calaveras County Water

District. If developments were undertaken under State Application 5648, it may be necessary for the California Water Commission to conduct a hearing.

During April 1963, the State Water Rights Board held hearings on the applications of the Calaveras County Water District, Stockton and East San Joaquin Water Conservation District, City of Stockton, and U. S. Bureau of Reclamation to determine the availability of water in the Calaveras River watershed. It is expected that the board will render its decision on these applications in the late summer of 1963. The California Water Commission, on May 4, 1962, granted a release from priority of Application 5648 at the New Hogan Dam in favor of the applications of the Calaveras County Water District for its upper Calaveras River Development.

CHAPTER V. PLANS FOR WATER DEVELOPMENT

The growth and enhancement of the economy of the Calaveras area will require the development of adequate water supplies at costs that future water users will be able to pay. In the Tributary and Main Stream Units of the area, there are curtailments of water use in critical periods that result in restrictions to further economic development. These restrictions affect the development of potential urban lands, optimum returns from presently irrigated lands, and the extent of development on irrigable lands not now being served. New water supplies will also be required for the further development of recreational potential and increased hydroelectric power output. Supplies for meeting current demands are obtained largely by diversions of unregulated surface waters through ditch systems of the Pacific Gas and Electric Company, the Calaveras County Water District, and the Calaveras Public Utility District.

In the Valley Unit of the area of investigation, present water demands are met by overdrawing ground water supplies, thereby causing progressive lowering of ground water levels. This overdraft results in increased pumping costs and the threat of degradation of mineral quality of ground water.

During the late winter and spring seasons, there are surplus flows in the streams of the Calaveras area. These flows, if properly controlled and distributed, would meet future water requirements of the area of investigation.

The discussion of plans for water development is presented in this chapter under the headings of "Planning Considerations," "Water Conservation Possibilities," "Calaveras Project," "Local Development Plans," "Partial Plan Proposed by the Calaveras County Water District," "Partial Plan Proposed by the Stanislaus River Basin Group," "New Melones Project," and "New Hogan Project."

Planning Considerations

Individual plans for developing the waters of the streams of the Calaveras area were conceived as parts of basinwide master plans. Under the basinwide plans, water would be developed for all beneficial purposes to obtain maximum net benefits. Development of water to meet the consumptive needs of the Calaveras area and planning for hydroelectric power developments so that revenue could be available to reduce the cost of project water supplies were considered to be of prime importance.

Formulation and evaluation of the projects considered for the development of waters in the Calaveras area required studies of reservoir operations, project site

geology, designs and cost estimates, and economic analysis of benefits and costs.

Reservoir Operation Studies

Reservoir operation studies to determine the water yield that would be available for both nonconsumptive and consumptive water use were made for the 35-year period 1920-21 to 1954-55. Nonconsumptive uses would include the production of hydroelectric energy, water-oriented recreation, and fish and wildlife preservation and enhancement. Consumptive uses would include irrigation and domestic uses. The principal criteria used in these studies included: (1) power capacity factor of 30 percent, (2) provision of minimum reservoir pools that would afford the adequate protection to fishlife, (3) streamflow releases sufficient to maintain a fishery even where a fishery does not now exist, (4) the need of water to satisfy the estimated future consumptive requirements of the Tributary and Main Stream Units, and (5) flood control incidental to the operation of the proposed reservoirs.

Geologic Investigations

The geologic exploration program for the Calaveras Area Investigation included: (1) surface geologic mapping of dam and reservoir sites, tunnel alignments, and conduit routes, (2) preliminary foundation drilling of certain key

dam sites, (3) collection of soil samples for testing to determine their construction properties, and (4) determination of quantities of available construction materials. In the geologic analysis of the individual sites, emphasis was placed on the determination of rock types, degree of weathering, patterns of jointing, nature and extent of shear zones, and the engineering properties of foundation materials. The program ranged from reconnaissance investigations of surficial geologic features at some sites, to detailed subsurface explorations at other sites in accordance with the size and significance of the proposed structures and the geologic problems encountered.

Complete reports of the results of geologic explorations of some of the damsites, conduit routes, and tunnel alignments are available in the files of the Department of Water Resources. These reports include drill hole logs, test results, geologic maps and cross sections, maps of locations of construction materials, and location of alternative sites.

Designs and Cost Estimates of Project Features

Engineering designs and estimates of cost were made of several sizes and types of dams for most of the sites considered. Structures were designed in accordance with standard engineering practices, with the objective of

obtaining the most economical combination of dam embankment, spillway, and outlet works. Stability characteristics of the earth embankments were based on laboratory tests of sample materials. In general, design floods were routed through the reservoirs, and spillways were sized to pass peak outflows.

Surveys and Maps. Topographic maps of the damsites considered and of the Spicer Meadow Reservoir area were prepared during the course of the investigation. The reservoir site map was prepared on the scale of 1 inch equals 400 feet, with a contour interval of 20 feet. Maps of damsites generally were prepared on the scale of 1 inch equals 150 feet, with a contour interval of 5 feet. Other maps used in the investigation were U.S. Geologic Survey quadrangles at the scale ratios of 1:62,500 and 1:24,000.

Cost Estimates

Estimates of capital cost of each project include construction costs of the dam and appurtenances, acquisition of land for damsites and reservoir areas, and relocation of facilities. Capital costs were based on unit prices prevailing in 1961. Allowance for 15 percent of the total cost for engineering administration and 25 percent for contingencies was made. Interest during construction was computed at 4 percent per annum for one-half the construction period. Annual costs include amortization of the capital investment

at an interest rate of 4 percent with a repayment period of 50 years, plus the annual costs of replacement, operation, maintenance, and general expense.

Estimates of the cost of acquiring existing hydroelectric power systems were based on the following procedure. The actual construction costs of the systems plus the costs of plant improvement since construction were obtained from the Board of Equalization. To this value was added the additional cost that would be required to rehabilitate the plant in order to make it equivalent to a new plant. The resulting value was reduced to annual costs. These annual costs were then compared to the annual costs of a steam plant. If the annual costs of the hydroelectric plant were less than the annual costs of a steam plant, the capitalized difference plus a contingency allowance was added to the values obtained from the Board of Equalization. Otherwise, the values obtained from the Board of Equalization, plus a contingency allowance, were used.

Economic Studies

The principal economic studies conducted to evaluate the possibilities for developing the water resources of the Calaveras area were: (1) determination of project benefits that would accrue from the operation of potential projects, and (2) project formulation and evaluation studies to determine the most favorable size and scope of potential

projects. As previously stated, economic studies were limited to those projects that would be required initially.

Project Benefits. Benefits from the projects considered herein would accrue primarily from irrigation and domestic water supplies, from production of hydroelectric energy, from fish and wildlife enhancement, and from new recreational opportunities.

All of the foregoing project benefit categories should be given full consideration in future, more detailed feasibility studies of the project; however, the only classes of benefits that were considered in this reconnaissance investigation were those attributable to hydroelectric power and recreational use. In determining project benefits, long-term projections were made of population growth and distribution, economic potential, and recreation use. For the purpose of making such projections, the following general assumptions were made.

1. Population would continue to increase to an estimated 420,000,000 in the United States, 56,000,000 in California, and 74,000 within the Calaveras area by the year 2020.

2. A relatively high level of employment and consumer demand would prevail during the period covered by the economic analysis.

3. Price-cost relationships would resemble those of the period 1952-56, especially with respect to agricultural production and returns.

4. Use of the proposed recreational areas and facilities would be substantially as projected herein.

Hydroelectric Energy Benefits. Hydroelectric benefits were represented by the cost of producing power by a private steam-electric plant. Northern and Central California were selected as the power market area. The anticipated magnitudes and characteristics of future power demand in this area were related to the estimated resources available to meet this demand. The area load and projection were analyzed to determine the proper relationship between dependable generating capacity and the average annual energy generated for the powerplants to be added by the projects considered herein. Power revenues were estimated after these magnitudes were determined.

It was concluded from detailed studies that future power requirements in Northern and Central California, based on anticipated population growth and annual energy use per capita, would provide a ready market for hydroelectric energy generated by the projects considered herein.

Based on the cost of producing equivalent power in a modern steam-electric plant, the value of hydroelectric power for the projects considered herein was estimated as \$24.50 per kilowatt per year of dependable capacity plus 3.1 mils per kilowatt hour of energy used.

Recreation and Fish and Wildlife Benefits. The recreational benefits that would accrue as a result of water project developments were measured by comparing the

estimated future water-oriented recreational activity in the area with and without the project. Factors considered in determining these benefits included trends in population growth and distribution, location of areas from which visitors would travel, existing recreation activities and facilities in the area, possible development of new types of outdoor recreation, and relative attractiveness of the area with competing areas.

Results of the studies of increased recreational use were expressed as visitor-days or angler-days of use per year. There would be continued increase of recreation use during the economic life of the project as the population of the State increases.

In project formulation studies, provisions were made for minimum reservoir pools, streamflow releases for the preservation and enhancement of fish and wildlife, and for lakeside and water-borne recreational opportunities. These provisions would increase the likelihood that recreational benefits would accrue. The estimated recreational benefits were utilized to make comparisons of alternative proposals and for benefit-cost analyses.

The recreational potential of streams affected by the various projects considered was evaluated by the Department of Fish and Game in terms of present and future angler-days of use. Present use was determined by sampling

surveys, interviews, and by counts of angling intensity and distribution. Future use of streams was projected on the basis of an estimated saturation in the year 2050. This projection allowed reasonable time for growth of facilities, for improvements in transportation and access, and for an increase in the amount of leisure time. Separate forecasts were made for conditions with and without each project, the difference in the forecasts representing the angler-days of use creditable to the potential project.

Although it is anticipated that both public and private recreational facilities would be located near the proposed reservoirs, the justification for public investment was restricted to those benefits derived from public facilities. The basic recreational facilities including access roads, provisions for sanitation control, drinking water, and public camping areas, would be provided by public funds. In order to insure development which would provide for wide public usage, all potential recreational lands adjacent to the reservoir sites would be obtained by land purchase or, if the land is in federal ownership, by use permit.

Economic Justification. A project may be considered to be economically justified when the present worth of the primary benefits that accrue therefrom are in excess of the present worth of the costs incurred in its design,

construction, operation and maintenance, and replacement. Comparison of benefits and cost in a project commonly is referred to as a benefit-cost ratio, and is utilized as a measure of the economic justification of the project. This ratio should not be the only criterion upon which feasibility is determined as it does not adequately reflect other intangible benefits or detriments that may be substantial.

Primary benefits are economic activities which arise from or are increased as a direct result of the building of a project. These benefits are expressible in dollars. Secondary benefits flow from or are increased by virtue of the existence of the primary benefits. While secondary benefits may be expressible in dollar values, the measurement of such values is often exceedingly difficult.

Costs used in the sizing studies included project capital costs, operation, maintenance, replacement, and in the case of hydroelectric plants, the taxes foregone.

Water Conservation Possibilities

Several possible means of obtaining additional water for use in the Calaveras area were considered during this investigation. Principal among these possibilities were: (1) direct diversion of streamflow, (2) increased ground water development, (3) increased use of water from existing conservation and distribution systems, and (4) further development of the unregulated surface waters of the Calaveras area.

Significant amounts of water in the Calaveras area are lost in transportation through existing distribution systems. These losses are attributable to both construction and operation of the systems. Gunnite lining of existing ditch systems would go far toward improving the effective yield of the available water supply in the Calaveras area.

Direct Diversion of Unregulated Streamflow

The possibilities for obtaining additional water from the Mokelumne, Calaveras, and Stanislaus River Basins for use within the area of investigation by direct diversions of unregulated streamflow are extremely limited. This is true because of the intermittent character of the small streams in the basins and because of wide fluctuations in monthly and annual runoff. The entire flow of these streams during periods of low runoff is utilized under existing water rights. A portion of this use takes place in Calaveras and Tuolumne Counties, but by far the greatest use takes place in irrigation districts located on the floor of the San Joaquin Valley. Therefore, because of the significance of existing water rights, direct diversion from streams was not considered as a means of developing new water supplies.

Increased Ground Water Development

The possibility of developing additional water supplies for use within the area of investigation by further ground water development was considered in the early stages of this investigation. However, study of existing ground water development in the higher elevations of the area revealed no ground water basins of significant size and storage capacity. Present ground water supplies are mostly obtained from wells located in shallow deposits of alluvium of limited extent. These wells are low yielding and generally supply only sufficient water for domestic and stock-watering purposes. On the other hand, the San Joaquin Valley portion of the area of investigation is underlain by a ground water basin of considerable importance. However, the extensive development of this ground water basin has resulted in progressive lowering of ground water levels.

After considering these factors the possibility of developing significant amounts of additional ground water supplies, as either an alternative or as a supplement to potential surface reservoirs, was deemed impractical.

Future Development of the Unregulated Waters of the Calaveras Area

Studies of the possibilities of developing, in storage reservoirs, unregulated waters of the Calaveras area

led to the conclusion that this was the most practical solution for providing substantial quantities of new water for use in the Tributary and Main Stream Units. Existing facilities in these units consist of the Utica Ditch System, distribution works of the Calaveras Public Utility District and the Calaveras County Water District, and small local developments of individual users and agencies. Due to present impairments and the wide variation in monthly and annual flows within the area, increased storage capacity would be required in order to further develop the remaining unregulated waters.

Potential projects for developing the waters of the Mokelumne, Calaveras, and Stanislaus River Basins were discussed in Bulletin No. 56, "Survey of Mountainous Areas," and in Bulletin No. 3, "The California Water Plan." The projects described in these bulletins were considered in formulating plans for projects discussed herein.

As shown on Plate 7, it is contemplated that the future requirements of the major units of the area of investigation as shown in Chapter III would be satisfied in the following manner:

1. Tributary Unit. Small water conservation projects would be constructed in upper Calaveras County to provide water for local consumptive

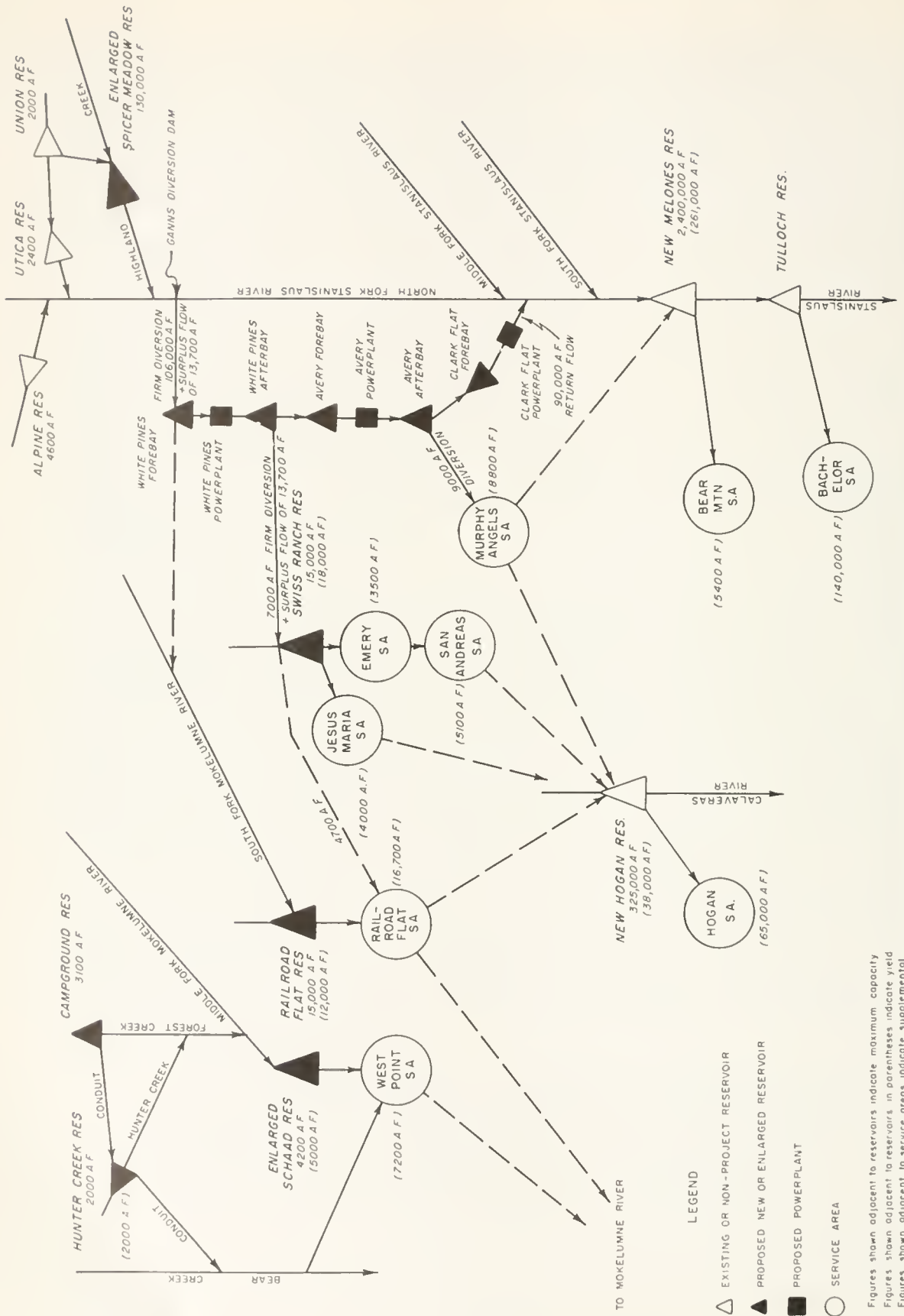


Figure 1. SCHEMATIC FLOW DIAGRAM

Figures shown adjacent to reservoirs indicate maximum capacity
 Figures shown adjacent to reservoirs, in parentheses indicate yield
 Figures shown adjacent to service areas indicate supplemental
 supplies required to year 2020

requirements. To supplement this source of supply, a project on the North Fork Stanislaus River would develop water for importation into upper Calaveras County for either direct diversion to areas of need or for reregulation in the small local projects.

2. Main Stream Unit. Lands within this unit would be served from the yield of New Melones Reservoir and New Hogan Reservoir supplemented by pumping from the Folsom South Canal.

3. Valley Unit. Irrigated and irrigable lands on the valley floor would continue to be served from ground water supplies supplemented by direct diversion from the Folsom South Canal.

The overall plan of development is shown in schematic form on Figure 1, "Schematic Flow Diagram of Water Supply Development, Calaveras Area."

Calaveras Project

The Calaveras Project, shown on Plate 8 and schematically in Figure 1, would develop a firm water supply of about 106,000 acre-feet annually. Provisions would be made for diverting approximately 16,000 acre-feet of this

water at various points for irrigation and domestic use within Calaveras County. The remaining 90,000 acre-feet of firm supply would be returned to the Stanislaus River for reregulation in the proposed New Melones Reservoir. It was estimated that the three powerplants would have a combined dependable capacity of 109,300 kilowatts and would produce an average annual amount of 350 million kilowatt-hours of energy.

New recreational opportunities would be realized by the project through the development of camp sites, boating facilities, and summer homes. Certain fisheries would be enhanced due to firming of the regimen of stream-flow in Highland Creek and North Fork Stanislaus River.

The Calaveras Project would include the diversion of water by tunnel from Union Reservoir on North Fork Stanislaus River to an enlarged Spicer Meadow Reservoir on Highland Creek. Water would be released from the enlarged Spicer Meadow Reservoir on demand and would flow down Highland Creek to its confluence with the North Fork Stanislaus River. At a point about 3 miles downstream from this juncture, at an approximate elevation of 5,280 feet, a low concrete diversion structure would divert water through a tunnel and conduit to the White Pines Forebay located on the headwaters of Little Mokelumne River at the Menzies Girl Scout camp. From this forebay, water

would be conveyed by conduit and penstock through the White Pines Powerplant to White Pines Afterbay on San Antonio Creek at an approximate streambed elevation of 3,940 feet. Water would be reregulated in this reservoir and then conveyed by conduit to Avery Forebay, located 1 mile northwest of the town of Avery at an approximate elevation of 3,850 feet. From this point, water would be discharged through Avery Powerplant into Avery Afterbay located directly west of the town of Avery, at an elevation of approximately 3,350 feet. From Avery Afterbay, water would be conveyed by conduit to Clark Flat Forebay, located on a ridge 1 mile northwest of the confluence of the Middle and North Forks Stanislaus River at an elevation of about 3,290 feet. From this forebay, water would be released into a penstock and discharged through Clark Flat Powerplant, located on the Stanislaus River at an elevation of approximately 1,140 feet, about 0.5 mile downstream from the confluence of the North and Middle Forks Stanislaus River.

Project Features

The Calaveras Project would consist of five major features, each of which is discussed below.

Spicer Meadow Unit. The Spicer Meadow Unit would consist of the Union-Spicer Tunnel and an enlarged Spicer

Meadow Reservoir formed by construction of an earth and rockfill dam immediately downstream from the existing Spicer Meadow Dam.

The Union-Spicer Tunnel would be 0.7 mile in length and would extend from Union Reservoir to Hobart Creek, a tributary discharging into Spicer Meadow Reservoir. The tunnel is planned as a horseshoe cross section, 7.5 feet in diameter, and would be unlined except at the portals and zones of weakness. The tunnel invert at the inlet portal would be set at an elevation of 6,840 feet and would slope toward Hobart Creek on a gradient of .009.

During high runoff periods, the entire inflow to Union Reservoir, up to the maximum capacity of the tunnel (300 second-feet), would be diverted to Spicer Meadow Reservoir. The maximum discharge capacity of the tunnel would be 300 second-feet and the flow would be entirely uncontrolled except for a trash rack and fish screen at the intake portal.

Storage in Union Reservoir at the tunnel invert elevation would be 1,000 acre-feet. This storage would be maintained throughout the recreation season. Streamflow maintenance releases into the North Fork Stanislaus River would be provided by operation of Utica Reservoir located immediately below Union Reservoir.

Spicer Meadow Dam (Plate 9) would be constructed immediately downstream from the existing structure at a streambed elevation of about 6,370 feet. Topographic maps of the damsite, at a scale of 100 feet to the inch with a contour interval of 10 feet, and of the reservoir area, at a scale of 400 feet to the inch with a contour interval of 20 feet, were prepared by the department in 1960. Areas and capacities of Spicer Meadow Reservoir are presented in Table 24.

TABLE 24

WATER DEPTHS, AREAS, AND CAPACITIES
OF ENLARGED SPICER MEADOW RESERVOIR

Reservoir	: :Water depth: : at dam, : in feet	:Water surface: elevation, : in feet : (USGS datum)	: Water : : surface:capacity, :area, in: in : acres	: Storage :acre-feet
Spicer Meadow	0	6,370	0	0
	10	6,380	2	20
	30	6,400	72	760
	50	6,420	195	3,500
	70	6,440	295	8,600
	90	6,460	405	15,600
	110	6,480	520	24,800
	130	6,500	700	36,800
	150	6,520	900	53,000
	154	6,524	960	57,000
	170	6,540	1,200	74,800
	190	6,560	1,500	102,000
Normal pool:	208	6,578	1,680	130,000
	210	6,580	1,700	133,500
	230	6,600	1,900	169,300

Geologic investigation of Spicer Meadow Dam and Reservoir site consisted of detailed geologic mapping, foundation drilling, and a borrow exploration program for possible construction materials. Results of the geologic investigations indicate that the site is suitable for a dam of the height contemplated in this investigation.

As the result of a materials exploration program conducted during this investigation, an adequate supply of impervious borrow material was located within 1.5 miles of the site. Quarry sites suitable for rockfill or riprap are available on both dam abutments and elsewhere in the immediate vicinity of the proposed dam.

Due to the availability of both pervious and impervious construction materials, a combination earth- and rockfill structure was selected for this site.

Preliminary sizing studies indicate that Spicer Meadow Reservoir should have a storage capacity of about 130,000 acre-feet. A dam having a height of 208 feet from streambed to spillway lip would be required to provide this storage. It would have a crest length of 1,950 feet and a crest width of 30 feet.

Spicer Meadow Reservoir would be operated to provide a firm yield on a power schedule of 106,000 acre-feet annually, and a fish release of 40 second-feet or the

natural flow at the point of diversion on North Fork Stanislaus River. Of this amount, 16,000 acre-feet of water would be diverted annually for irrigation and domestic use in portions of upper Calaveras County. A constant release of at least 5 second-feet, for fishery maintenance, would be provided from Spicer Meadow Reservoir.

A monthly operation study of Spicer Meadow Reservoir, for the critically dry period 1927-28 through 1934-35, is included on a seasonal basis in Table 28.

Ganns Diversion Unit. The Ganns Diversion Unit would consist of a low concrete dam on North Fork Stanislaus River and 13.5 miles of tunnel and conduit necessary to convey water to White Pines Forebay.

Ganns Diversion Dam would be a concrete arch structure about 25 feet in height located in the NE 1/4, of the NW 1/4, of Section 8, T6N, R17E, MDB&M at an approximate streambed elevation of 5,280 feet. Topography of the damsite and reservoir area was taken from the U. S. Geological Survey river survey map of the Stanislaus River at a scale of 1 inch equals 2,000 feet with a contour interval of 20 feet.

No detailed geologic studies have been made at this site. However, limited geologic reconnaissance studies including study of the regional geology presented in Plate 5, indicate that the Ganns Diversion site would be suitable for construction of a low masonry structure.

Generally, the North Fork Stanislaus River is a deeply incised canyon with walls of blocky and massive granitic rock which have been exposed by glaciation. The channel section of this stream is generally very narrow and contains large boulders and talus blocks.

Ganns Diversion Dam would serve as a forebay for Ganns Tunnel and conduit. In addition, the dam will contain outlet works sufficient for a constant release of up to 40 second-feet for fishery maintenance purposes. As shown on Table 28, the firm seasonal diversion would be 106,000 acre-feet and a summary of a critical seven-year period indicates that a seasonal average diversion of 128,000 acre-feet may be expected.

Water from Ganns Diversion Reservoir would discharge into the Ganns conduit. The first portion of this conduit would be an unlined tunnel with a diameter of 10 feet and 5.2 miles in length. The intake portal would be at an elevation of about 5,285 feet. The tunnel would extend in a generally southwesterly direction, roughly paralleling the course of North Fork Stanislaus River, and would discharge into a lined canal in the SE 1/4 of Section 28, T6N, R16E, MDB&M, at an approximate elevation of 5,200 feet. The capacity of Ganns conduit would be 400 second-feet.

White Pines Unit. The White Pines Unit would consist of White Pines Forebay, White Pines Powerplant, White Pines Afterbay, and Avery Conduit.

White Pines Forebay would be located on the headwaters of Little Mokelumne River at an elevation of approximately 5,140 feet. The forebay would be formed by an earthfill dam 50 feet in height with a crest length of 1,100 feet. Storage capacity would be about 250 acre-feet. Outlet works would consist of a pipe fitted with remote control valves sufficiently large to pass about 550 second-feet of water through the dam. The outlet works would include a branch stub connection to provide for a future diversion to the Railroad Flats Reservoir.

From White Pines Forebay, a canal having a capacity of 510 second-feet, would extend a distance of 6,500 feet to the White Pines Penstock for water discharged through White Pines Powerplant into White Pines Afterbay.

White Pines Powerplant, which would have an installed capacity of 38,000 kilowatts, would be located on San Antonio Creek at an elevation of about 4,010 feet, and would operate under a static head of 1,120 feet. The penstock, with an inlet elevation of 5,130 feet, would be 81 inches in diameter, and 5,500 feet in length.

White Pines Afterbay would be formed by construction of a dam on San Antonio Creek at streambed elevation of 3,940 feet. Areas and capacities of White Pines Afterbay are presented in Table 25. Based on detailed geologic

studies, the White Pines Afterbay site is considered adequate for an earthfill dam of the size under consideration in this report.

TABLE 25
AREAS AND CAPACITIES
OF WHITE PINES AFTERBAY

Water surface : elevation, in feet :	Area, in acres :	Storage capacity, in acre-feet :
3,940	0	0
3,960	4	40
3,980	20	260
4,000	38	840
4,020	54	1,770

As a result of geologic studies and design criteria, an earth dam with an impervious core was selected for the White Pines site. The dam would have a height of 70 feet from streambed to spillway lip and a crest elevation of 4,010 feet. The crest length would be 530 feet with a width of 30 feet. The volume of fill required would be about 273,000 cubic yards. Sufficient material for the fill is located adjacent to the damsite.

The outlet works would consist of a concrete pipe with a maximum capacity of about 540 second-feet through the dam. The outlet works would be designed to make a

controlled release of 80 second-feet directly into San Antonio Creek below the dam, with the remaining 460 second-feet discharging into the Avery Conduit.

The reservoir area consists mostly of privately owned lands, although a small portion is U. S. Forest Service land. There are no improvements or utilities within the reservoir area.

The Avery Conduit would convey a maximum of 460 second-feet of water from White Pines Afterbay to Avery Forebay, a distance of 6.9 miles. The conduit would include 1,000 feet of 6.5-foot diameter, lined tunnel; 1,120 feet of 6.75-foot diameter steel pipe siphon; 2,450 feet of 5.25-foot diameter steel pipe siphon; and 31,330 feet of lined trapezoidal canal. The conduit would terminate at an elevation of about 3,895 feet.

A topographic map of the Avery Conduit route, at a scale of 1 inch equals 300 feet and with a contour interval of 10 feet was compiled in 1959 by the department, using photogrammetric methods.

Avery Unit. The Avery Unit would consist of Avery Forebay, Avery Powerplant, Avery Afterbay, and Clark Flat Conduit.

Avery Forebay would be located in a small saddle about 1 mile northwest of the town of Avery, at an approximate

elevation of 3,870 feet. The area was mapped by photogrammetric methods at a scale of 1 inch equals 300 feet, with contour interval of 10 feet. In 1957 the department produced a planetable map of the area at a scale of 1 inch equals 100 feet, with a contour interval of 5 feet.

A geologic mapping and materials investigation of the site was made in 1958. Thirteen auger holes were drilled to a total depth of 323 feet. The geologic investigation indicated that the site would be suitable for the type of dam contemplated.

The reservoir would be formed by 2 dikes, one of which would be about 15 feet high with a crest length of about 1,400 feet, and the second of which would be about 25 feet in height with a crest length of approximately 2,200 feet. Crest elevation of both dikes would be 3,885 feet. The forebay capacity would be 90 acre-feet.

From Avery Forebay, a lined canal 4,500 feet in length, with a capacity of 460 second-feet, would convey water to the Avery Penstock. The penstock would discharge water through Avery Powerplant, at an approximate elevation of 3,385 feet, into Avery Afterbay. Avery Powerplant would have an installed capacity of 15,100 kilowatts.

Avery Afterbay would be located in the NE 1/4, of Section 13, T4N, R14E, MDB&M, on San Domingo Creek at a streambed elevation of 3,355 feet. A topographic map of the

site was prepared by planetable methods in 1957 at a scale of 1 inch equals 200 feet with a contour interval of 5 feet.

The outlet works would consist of concrete pipe through the dam sufficiently large to release about 400 second-feet. The releases would be made directly into Clark Flat Conduit with provision for further releases into San Domingo Creek.

Clark Flat Conduit would deliver water from Avery Afterbay to Clark Flat Forebay through 17,850 feet of conduit including 3,100 feet of flume, 11,600 feet of lined canal, 2,900 feet of siphon, and 250 feet of pipe culvert. The conduit would have a capacity of 360 second-feet. It would terminate above Clark Flat Forebay at an elevation of 3,314 feet.

Clark Flat Unit. The Clark Flat Unit would consist of Clark Flat Forebay, Clark Flat Penstock and Clark Flat Powerplant.

Clark Flat Forebay would be located in the NE 1/4, NE 1/4, Section 36, T4N, R14E, MDB&M at an approximate elevation of 3,300 feet. The reservoir would be formed by excavation and construction of a U-shaped dike. The dike would impound 40 acre-feet of water with a maximum surface area of about 4 acres.

Releases would be made directly from the forebay into Clark Flat Penstock at an intake elevation of approximately 3,300 feet. Water would be conveyed through Clark Flat Powerplant to discharge directly into the Stanislaus River.

The powerplant would be located in the SW 1/4, SW 1/4, Section 31, T4N, R15E, MDB&M at an approximate elevation of 1,140 feet. The gross head on the powerplant would be 2,160 feet with a head loss of approximately 50 feet. The installed capacity of the powerplant would be 56,200 kilowatts.

Estimated capital and annual costs of the Calaveras Project are presented in Table 26.

General features of the Calaveras Project are summarized in Table 27, and a seasonal summary of a monthly operation study of the project for the critically dry period 1927-28 through 1934-35 is presented in Table 28.

Purchase of the Utica System. The Utica System is described in detail in Chapter III as a present water supply development of the North Fork of the Stanislaus River. The system is owned by the Pacific Gas and Electric Company and consists of three reservoirs, two powerplants and a diversion ditch. The total installed power generation capacity of the two plants is 5,000 kilowatts. Although a

Feature	Annual costs			50-year repayment period		
	: Operation and maintenance			: Present worth of		
	: Capital	: annual	: recovery*	: Capital	: operation and	: Totals
	\$	\$	: maintenance: equivalents)	\$	cost : maintenance	\$
Union Spicer Tunnel	\$ 34,400	\$ 2,900		\$ 738,000	\$ 62,300	\$ 800,300
Spicer Meadow Dam and Res.	218,400	32,600		4,691,000	700,300	5,391,300
Ganns Diversion Dam	7,000	1,000		150,000	21,500	171,500
Ganns Tunnel	334,500	3,600		7,185,000	77,300	7,262,300
Ganns Conduit	56,400	12,100		1,212,000	259,900	1,471,900
White Pines Forebay	20,900	1,000		450,000	21,500	471,500
White Pines Powerplant	442,200	155,000		8,924,000	3,329,700	12,253,700
White Pines Afterbay	51,400	1,000		1,105,000	21,500	1,126,500
Avery Conduit	101,200	13,600		2,173,000	292,200	2,465,200
Avery Forebay	9,100	1,000		196,000	21,500	217,500
Avery Powerplant	221,800	101,000		4,477,000	2,169,700	6,646,700
Avery Afterbay	8,700	1,000		186,000	21,500	207,500
Clark Flat Conduit	54,200	11,200		1,165,000	240,600	1,405,600
Clark Flat Forebay	6,700	1,000		143,000	21,500	164,500
Clark Flat Powerplant	426,000	196,000		8,598,000	4,210,500	12,808,500
Purchase Utica System	147,500	12,500		3,168,000	268,500	3,436,500
Recreational Facilities**				3,117,500	1,383,400	4,500,900
TOTALS	\$2,140,400	\$546,500		\$47,678,500	\$13,123,400	\$60,801,900
	Taxes foregone			Present worth of taxes foregone		21,159,800
	TOTALS					\$81,961,700

Item	Benefits		
	: Average annual		
	: equivalents	: worth	: Benefit-cost ratio
Power***	\$3,795,600	\$81,537,100	
Recreation		7,624,200	
TOTALS	\$3,795,600	\$89,161,300	\$89,161,300 = 1.12:1 \$81,961,700

* At 4% interest rate.

** Recreational facilities would be built in stages as required.

*** Power benefits are based on a power capacity factor of 30% over the full 50-year period.

TABLE 27

GENERAL FEATURES OF THE CALAVERAS PROJECT

Dam and Reservoir	Stream	Location, MDB&M	Height:length, in feet:in feet:	Crest : pool : elevation: : storage,	Normal : : in acre-feet	Gross : storage,
Spicer Meadow	Highland Creek	S9, T6N, R18E	221	1,950	6,578	130,000
Ganns	N. F. Stanislaus R.	S8, T6N, R17E	25	--	5,300	--
White Pines Forebay	Little Mokelumne R.	S3, T5N, R15E	50	1,100	5,180	250
White Pines Afterbay	San Antonio Creek	S21, T5N, R15E	80	530	4,010	1,260
Avery Forebay		S12, T4N, R14E	25	2,200	3,880	90
Avery Afterbay	San Domingo Creek	S13, T4N, R14E	25	550	3,375	160
Clark Flat Forebay		S36, T4N, R14E	50	--	3,340	40
Powerplant	Location, MDB&M	Net : dependable : head, : capacity, in : in feet: kilowatts :	Installed and: : Dependable :	seasonal : : energy, : flow, in : in MWH : second-feet		
White Pines	S16, T5N, R15E	1,092	38,000	99,864	509	
Avery	S13, T4N, R14E	484	15,100	39,683	460	
Clark Flat	S31, T4N, R15E	2,110	56,200	147,694	360	
Total System		3,686	109,300	287,421		
Conduit	Type	:Capacity in second-feet: Length in miles				
Union-Spicer	Tunnel	300				0.7
Ganns	Tunnel and canal	400				13.5
White Pines-Avery	Canal	460				6.9
Avery-Clark Flat	Canal	360				3.4

SEASONAL SUMMARY OF MONTHLY OPERATION STUDY OF CALAVERAS PROJECT

Water Budget Item	Water Years													
	:1927-28:	1928-29:	1929-30:	1930-31:	1931-32:	1932-33:	1933-34:	1934-35:	Average					
Spicer Meadow Reservoir														
Storage October 1	108,500	94,700	72,000	82,400	30,900	86,100	72,100	41,000				72,200		
Inflow (including Union Tunnel supply)	90,200	61,100	82,000	43,000	122,800	70,000	55,700	128,100				81,600		
Subtotal	198,700	155,800	154,000	125,400	153,700	156,100	127,800	169,100				153,800		
Evaporation	4,500	3,900	4,000	3,000	3,500	3,700	3,100	4,000				3,700		
Release to Ganns Diversion *	99,500	79,900	67,600	91,500	64,100	80,300	83,700	74,200				80,100		
Ganns Diversion Dam														
Inflow (including Spicer Meadow supply)	210,300	146,900	166,900	130,700	226,300	160,900	141,600	220,400				175,500		
Fish release and spill	66,900	26,200	37,900	20,600	85,000	31,100	23,200	87,800				47,300		
Total diversion to White Pines	143,400	120,700	129,000	110,100	141,300	129,800	118,400	132,600				128,200		
Safe power yield to White Pines	106,100	106,100	106,100	106,100	106,100	106,100	106,100	106,100				106,100		
Excess diversion possible	37,300	14,600	22,900	4,000	35,200	23,700	12,300	26,500				22,100		
Firm diversion to Swiss Ranch	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000				7,000		
Excess possible diversion to Swiss Ranch	21,800	10,200	14,400	1,000	22,100	15,800	8,400	15,800				13,700		
Firm diversion to Murphys-Angels	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000				9,000		
Firm return flow to N. Fork Stanislaus R.	90,100	90,100	90,100	90,100	90,100	90,100	90,100	90,100				90,100		
Power Production														
(water in acre-feet, power in MWH)														
Water diverted through White Pines Powerplant	143,400	120,700	129,000	110,100	141,300	129,800	118,400	132,600				128,200		
Energy produced at White Pines Powerplant	136,158	114,605	122,486	101,691	134,164	123,245	113,370	125,904				121,453		
Water diverted to Swiss Ranch	28,800	17,200	21,400	8,000	29,100	22,800	15,400	22,800				20,700		
Water supply at Avery Powerplant	114,600	103,500	107,600	102,100	112,200	107,000	103,000	109,800				107,500		
Energy produced at Avery Powerplant	47,942	43,300	44,977	41,444	46,939	44,735	43,480	45,906				44,840		
Water diverted to Murphys-Angel Service Ar.	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000				9,000		
Water supply at Clark Flat Powerplant	105,600	94,500	99,500	90,100	103,200	98,000	95,000	100,800				98,300		
Energy produced at Clark Flat Powerplant	197,864	177,073	186,457	168,757	193,369	183,498	177,879	188,742				184,135		
TOTAL ENERGY PRODUCED														
	381,964	334,978	353,920	311,892	374,472	351,478	334,729	360,552				350,428		
*Including 3,600 fish release														

*Including 3,600 fish release

maximum of 88 second-feet are diverted from the river through the Utica Ditch, the company is limited in their firm water right to 55 second-feet at the Murphys Powerplant. Subject to this right, all of the 88 second-feet may be distributed and applied in the Calaveras area.

A definitive plan for the utilization of the Utica System is beyond the scope of this reconnaissance investigation. In all probability, however, any plans for water supply development in this part of the investigative area would incorporate this system to be operated with other contemplated project facilities as an integral unit. Further study may show that some of the existing power generation water requirements of this system are compatible with other project water requirements, in which case the full purchase of this system would not be required. However, for purposes of this report, it has been assumed that it would be necessary to purchase the Utica System in order to insure the required flexibility of operations for the Calaveras Project.

Project Accomplishments

The objective of the Calaveras Project would be to make water from the North Fork Stanislaus River available to Calaveras County for beneficial use at a reasonable cost.

By providing a conduit system along the ridge immediately north of the North Fork of the Stanislaus River, it would be possible to release water to several interior areas of the county for direct local use or for reregulation by means of a system of "local development" projects. These projects would be constructed only at such times and locations as would be economically and financially feasible. In determining the economic justification of the Calaveras Project, previously shown in Table 26, the benefits that would accrue from the use of water for agricultural, municipal, or industrial purposes were not included. However, under the concepts applied in this reconnaissance investigation, water could be made available from the Calaveras Project on the ridge at no cost to the water user.

The Calaveras Project would provide for an initial firm yield of 16,000 acre-feet to Calaveras County, as shown in Figure 1. Furthermore, as shown in the seasonal operations study presented in Table 28, an average annual total yield of 38,000 acre-feet, including diversions of nonfirm water, would be available for conveyance to Railroad Flat Reservoir, Swiss Ranch Reservoir, and the Murphy-Angels Service Area. Preliminary operation studies of these reservoirs indicate that, by reregulating this water,

provision could be made to supply all predicted water requirements of the service areas dependent upon this system.

Primary Benefits. For purposes of the analyses presented herein, the primary benefits accruing to the project are attributable to hydroelectric power generation and to recreational activities.

The benefits which would accrue to the generation of hydroelectric power were developed from operational studies which are summarized in Table 28, "Seasonal Study of Monthly Operation Study of Calaveras Project." The analysis was based on planned diversions for local use from two reaches of the project at points upstream and downstream of Avery Powerplant. A possible future diversion could be made upstream of White Pines Forebay but was not considered in the operation study presented herein.

The estimates of power produced by the project are considered to be conservative because the study was based on the available water supply depleted by diversions for urban and agricultural use as predicted by the year 2020. In other words, the water that would be available for power production would be in excess of that shown in the operation study and would progressively reduce to the figures shown in the study during the 50-year period.

The optimum sizes of powerplants were determined from the firm yield of water that would be available at each site. The generation capacity which corresponds to this firm yield is the dependable capacity. Table 28 shows that the average annual power production over the critical seven-year study period would be 350,428,000 KWH. Based on the estimated cost of power production by an alternative thermal powerplant, the power benefits which would apply to the Calaveras Project have been estimated to be \$24.50 per kilowatt of dependable capacity per year, plus 3.1 mills per kilowatt-hour of energy produced. The dependable energy component would thus be 109,300 KW at \$24.50, or \$2,677,800. The energy component would be 350,428,000 KWH at 3.1 mills, or \$1,117,800. The total annual power benefit which would accrue to the project would be \$3,795,600, and the corresponding present worth of the power benefit would be \$81,537,100.

Recreation Benefits. Recreation benefits have been estimated for three reservoirs which appear to have definite recreational potential. The estimated recreational use of these facilities was evaluated by decades in order properly to consider the effect of population growth and concomitant recreational requirements. The value of a visitor-day of use in the Calaveras area was determined to be

about \$2.23. This figure, which was developed by the Trice-Wood method, has been reduced to \$2.20 for use in this report. Table 29 shows the total present worth of recreational benefits would be about \$7,624,200.

Project Costs. The estimated costs of the Calaveras Project are discussed in terms of the average equivalent, taxes foregone and present worth, and they are summarized in Table 26.

TABLE 29
RECREATION BENEFITS,
CALAVERAS AREA

Site	: Decade :mid-point:	: Annual use :(1,000 visitor-days)	: Decade: benefit:\$1,000)	:Present: worth:factor	:Present: worth of benefit
Spicer Meadow	1975	400	880	.8219	\$723,300
	1985	580	1,276	.5553	708,600
	1995	760	1,672	.3751	627,200
	2005	940	2,068	.2534	524,000
	2015	1,140	2,058	.1712	429,400
White Pines	1975	400	880	.8219	723,300
	1985	580	1,276	.5553	708,600
	1995	760	1,672	.3751	627,200
	2005	940	2,068	.2534	524,000
	2015	1,140	2,058	.1712	429,400
Avery	1975	220	484	.8219	398,000
	1985	300	660	.5553	366,500
	1995	400	880	.3751	330,000
	2005	500	1,100	.2534	278,700
	2015	600	1,320	.1712	226,000

Total Present Worth of Recreation Benefits-\$7,624,200

The average equivalent is a theoretical figure used to establish for comparative purposes a uniform annual cost or benefit throughout the 50-year repayment period. The average annual equivalent cost of the Calaveras Project equals the annual cost of operation and maintenance added to the product of the capital cost and a capital recovery factor of 0.04655. This particular capital recovery factor represents the uniform annual end-of-year payment necessary to repay the debt in 50 years with interest at 4 percent.

Taxes foregone are the yearly taxes lost when a public rather than a private agency develops power. It is the established policy of the Department of Water Resources to show these taxes foregone as a cost item in considering the economic justification of a project. The value of this cost item is equivalent to the taxes that would be paid by an equivalent project if it were developed by a private power company.

From the viewpoint of the agency making the investment, the present worth of a future expenditure or series of expenditures is the present money value necessary to secure the return of that future expenditure with interest at a given rate of interest--4 percent in this case. The present worth of operation and maintenance costs of the Calaveras Project is the product of the average annual cost and 21.82 (the present worth factor).

Benefit-Cost Ratio. The benefit-cost ratio of the Calaveras Project is estimated to be 1.12:1. The Calaveras Project is thus justified from an economic standpoint. Table 26 shows the benefit-cost ratio as well as a summary of the benefits and costs.

Revenues. It is assumed that the agency which would operate the Calaveras Project would be a public entity, and therefore exempt from taxes. Excluding the item of taxes foregone the present worth of actual costs of the project would be \$60,801,900. A portion of this capital cost would be allocated to recreation and therefore nonreimbursable. The present worth of power benefits, which are equivalent in this case to revenue, would be \$76,652,100. Thus the present worth of surplus revenue exceeds the present worth of annual project costs by the difference between the revenue from hydroelectric power and the amount of capital cost allocated to hydroelectric power. This represents on an annual basis a surplus in excess of \$737,800, the amount that potentially would be available to finance the expansion of local projects in Calaveras County which might require such an impetus for economic growth. Because of the reconnaissance nature of this investigation, cost allocation studies were not made. Any feasibility studies to be conducted in the future should provide a more

detailed analysis of costs and benefits in accordance with accepted procedures.

Local Development Plans

In order to meet the year 2020 water requirements of the various service areas within the Tributary and Main Stream Units of the Calaveras area, reconnaissance studies were made of possible dam and reservoir sites that could be developed to supply water for local use. Sites studied during previous investigations were reviewed and evaluated with respect to their possibilities for serving local areas.

The formulation of plans for the development of water resources is normally achieved by evolving estimates of costs and benefits that would accrue for a range of project sizes in order to arrive at a project that would provide a maximum of net benefits. During this process, an estimate of future water requirements must be derived by considering the classification of lands and the capacity of these lands to repay the costs of water supplies. These considerations establish a limit on the amount of land which could be irrigated and thus determine the water requirement for irrigation purposes. A similar approach is used to establish the water requirement for other purposes.

Based upon these water requirements, a trial project is planned to fulfill these demands, and the unit cost of water as delivered to the user by this system is estimated. The cost of the water must be within the repayment capacity of the users.

During the course of this investigation, reconnaissance plans of several individual projects were considered to satisfy a single set of water requirements which was based on an estimated repayment capacity by the water users of \$5-10 per acre foot, as shown in Table 23. The reconnaissance plans of projects discussed in this section are believed to be the most promising of these studies. However, future formulation studies, including better information for project economic justification and financial feasibility analyses, may substantially modify these plans.

West Point Project

The West Point Project, shown schematically in Figure 1, would consist of three reservoirs in or adjacent to the West Point Service Area. This project contemplates the enlargement of the existing Schaad Reservoir on Middle Fork Mokelumne River and the construction of Campground and Hunter Creek Reservoirs on Hunter Creek. The project would serve the year 2020 needs of the West Point Service Area which are estimated to be about 7,200 acre-feet.

Enlarged Schaad Reservoir. The existing Schaad Reservoir on Middle Fork Mokelumne River is located in the SW 1/4, S9, T6N, R14E, MDB&M at a streambed elevation of 2,840 feet. This reservoir is owned and operated by the Calaveras Public Utility District for local use within the Wilseyville area and for export to the South Fork Mokelumne River for subsequent use in Mokelumne Hill and San Andreas.

Schaad Reservoir would be enlarged from its present capacity of 1,700 acre-feet to a capacity of 4,200 acre-feet with a corresponding firm yield of 5,000 acre-feet per year. A topographic map of the damsite at a scale of 1 inch equals 100 feet, with a contour interval of 5 feet was prepared in 1961. The reservoir area was also mapped in 1961, at a scale of 1 inch equals 300 feet, with a contour interval of 10 feet. These maps were prepared by the Department of Water Resources using photogrammetric methods. Storage capacities and corresponding firm yields at various stages of elevation are given in Table 30.

Based on surficial geologic studies, the Schaad damsite is considered suitable for a zoned earthfill dam of the size under consideration.

The result of geologic investigation, a zoned earthfill dam 135 feet in height from streambed to spillway

lip and with a crest elevation of 2,988 feet, was selected for the Schaad site. Removal of the existing dam, which is about 95 feet in height, would be necessary. Sufficient material for the pervious and impervious sections is available in the immediate vicinity. The volume of fill required would be about 900,000 cubic yards.

TABLE 30
AREAS AND CAPACITIES OF ENLARGED SCHAAD RESERVOIR

Water surface elevation, in feet	:	:	:	Area, in acres
	:	Storage capacity	:	
2,840	:	0	:	0
2,890	:	700	:	28
2,910	:	1,300	:	38
2,930	:	2,200	:	53
2,950	:	3,400	:	67
2,970	:	4,880	:	82
2,990	:	6,750	:	100

Campground Reservoir. Campground Dam would be located in the NW 1/4, S33, T7N, R15E, MDB&M on Forest Creek at a streambed elevation of about 4,500 feet. A topographic map of the damsite was prepared in 1960 at a scale of 1 inch equals 150 feet, with a contour interval of 5 feet. The

reservoir area was mapped at a scale of 1 inch equals 300 feet with a contour interval of 10 feet. These maps were prepared by the Department of Water Resources using photogrammetric methods. Storage capacities of the proposed Campground Reservoir at various stages of water surface elevation are presented in Table 31.

TABLE 31
AREAS AND CAPACITIES OF CAMPGROUND RESERVOIR

Water surface elevation, in feet	:	Storage capacity in acre-feet	:	Area, in acres
4,500	:	0	:	0
4,520	:	5	:	1
4,540	:	150	:	16
4,560	:	740	:	37
4,580	:	1,600	:	58
4,600	:	3,100	:	91

Based on a surficial geologic investigation, the Campground damsite is suitable for the construction of a zoned earthfill dam of the size under consideration in this report. The reservoir area contains no utilities and the only relocation necessary would be about 1-1/4 miles of dirt road. No leakage would be anticipated and silting would be light.

As a result of yield studies, geologic investigation, and design criteria, an earthfill dam 110 feet in height, with a crest elevation of 4,610 feet, and a crest length of about 1,000 feet was chosen for this site. The volume of fill would be about 410,000 cubic yards. Sufficient material would be available in the immediate vicinity of the site.

The outlet works would consist of a 30-inch diameter welded steel pipe encased in concrete along the right abutment. The outlet works would discharge water directly into a conduit for transportation to Hunter Creek, with provisions for releases directly into Forest Creek.

Forest Creek to Hunter Creek Conduit. This conduit would convey water from Campground Reservoir to Hunter Creek Reservoir, and would be approximately 5.6 miles in length with a capacity of 15 second-feet.

Hunter Creek Reservoir. Hunter Creek Dam would be located on Hunter Creek in the NW 1/4, S26, T7N, R14E, MDB&M at a streambed elevation of 4,195 feet. A topographic map of the damsite was prepared at a scale of 1 inch equals 150 feet with a contour interval of 5 feet and the reservoir area was mapped at a scale of 1 inch equals 300 feet with a contour interval of 10 feet. These maps were produced in 1960 by the Department of Water Resources, using photogrammetric

Methods. Storage capacities of the proposed Hunter Creek Reservoir at various water surface elevations are presented in Table 32.

TABLE 32

AREAS AND CAPACITIES OF HUNTER CREEK RESERVOIR

Water surface elevation, in feet	:	Storage capacity, in acre-feet	:	Area, in acres
4,220	:	0	:	0
4,250	:	40	:	4
4,260	:	100	:	9
4,270	:	230	:	17
4,280	:	440	:	25
4,290	:	730	:	33
4,300	:	1,100	:	41
4,310	:	1,570	:	51

Based on a surficial geologic investigation, the Hunter Creek damsite is considered suitable for a zoned earthfill dam of the size under consideration in this report. The reservoir area contains no roads or utilities. No leakage problem exists and silting should be light.

As a result of yield studies, geologic investigation, and design criteria, an earthfill dam 115 feet in height from streambed to spillway lip and with a crest elevation of 4,310 feet was selected. The volume of fill required

would be about 420,000 cubic yards. Sufficient construction material is available in the immediate vicinity.

The outlet works would consist of a 30-inch diameter welded steel pipe encased in concrete along the left abutment and would discharge into the Hunter Creek to Bear Creek conduit with provision for direct releases to Hunter Creek.

Hunter-Bear Creek Conduit. This conduit would be lined trapezoidal canal about 3.5 miles in length with a capacity of 15 second-feet. The conduit would convey the combined yield of Campground and Hunter Creek Reservoirs. to Bear Creek for subsequent conveyance through an existing distribution system in the West Point Service Area.

Estimated capital and annual costs of the various features of the West Point Project are presented in Table 33.

Railroad Flat Project

The Railroad Flat project, shown schematically in Figure 1, would consist of Railroad Flat Reservoir on South Fork Mokelumne River and would contemplate use of the existing Mokelumne Ditch and the construction of additional distribution ditches in the Mokelumne Hill and Paloma areas. The southwest portion of the Railroad Flat Service Area would be the principal area served with water from Railroad Flat Reservoir. It was not deemed financially feasible to

SUMMARY OF ESTIMATED CAPITAL AND ANNUAL COSTS, WEST POINT PROJECT

Project Unit	Capital Costs						Total
	Project : : construction:	Contingencies:	Eng. : : and : admin.	Interest : : during : construction:	Land :		
					acquisition:		
Enlarged Schaad Reservoir	\$1,594,000	\$320,500	\$288,000	\$64,000			\$2,267,000
Campground Dam and Reservoir	825,800	165,200	148,000	33,000	\$14,000		1,186,000
Hunter Creek Dam and Reservoir	871,900	174,100	157,000	35,000	7,000		1,245,000
Forest Creek-Hunter Creek Conduit	260,000	52,000	47,000	10,000	4,000		373,000
Hunter Creek-Bear Creek Conduit	146,200	29,800	26,000	6,000	2,000		210,000
Total Capital Costs	\$3,697,900	\$741,600	\$666,000	\$148,000	\$27,000		\$5,281,000

Project Unit	Annual Costs			Total
	Capital	Operations,		
	: recovery*	: maintenance**		
Enlarged Schaad Reservoir	\$105,000	\$ 5,000		\$110,000
Campground Dam and Reservoir	55,200	1,200		56,400
Hunter Creek Dam and Reservoir	58,000	800		58,800
Forest Creek-Hunter Creek Conduit	17,400	3,700		21,100
Hunter Creek-Bear Creek Conduit	<u>9,800</u>	<u>2,100</u>		<u>11,900</u>
	<u>\$245,400</u>	<u>\$12,800</u>		<u>\$258,200</u>

* Capital recovery annual cost is based on a 50-year series at 4% rate of return, i.e., the capital recovery factor = .04655.

** Includes an allowance for replacement cost and administrative and general expense.

attempt to develop water for the northeast portion of this service area at this time for reasons presented in the discussion of McCarty Reservoir. The year 2020 requirements of the southwest portion of Railroad Flat Service Area are estimated to be 12,000 acre-feet per year. The Railroad Flat Project would supply about 9,000 acre-feet of water; the remaining 3,000 acre-feet would be supplied by the Swiss Ranch project described later in this chapter.

Railroad Flat Dam would be located in the NE 1/4 S23, T6N, R13E, MDB&M at a streambed elevation of about 2,150 feet. A topographic map of the damsite at a scale of 1 inch equals 200 feet with a contour interval of 50 feet was made by the East Bay Municipal Utility District in 1953. The reservoir area was mapped by planetable survey by the Department of Water Resources in 1957 at a scale of 1 inch equals 200 feet. Storage capacities of Railroad Flat Reservoir at various stages of elevation are presented in Table 34.

TABLE 34
AREAS AND CAPACITIES OF RAILROAD FLAT RESERVOIR

Water surface elevation, in feet	:	Storage capacity, in acre-feet	:	Area, in acres
2,135	:	0	:	0
2,200	:	1,000	:	40
2,240	:	4,000	:	110
2,280	:	10,000	:	185
2,320	:	19,000	:	275
2,360	:	31,000	:	350
2,400	:	47,000	:	450

A surficial investigation of the site was made by the department in 1951. Based on this investigation, the site appears favorable for a rockfill dam with an impervious core of the size under consideration in this report.

The reservoir would inundate a portion of the Wilseyville-Railroad Flat county road, necessitating about one mile of relocation across the top of the dam. In addition, a secondary power transmission line would have to be relocated across the top of the dam.

As a result of yield studies, a dam 170 feet in overall height, creating a reservoir with a storage capacity of 15,000 acre-feet, was chosen for this site. The crest elevation would be 2,320 feet. Sufficient construction material is available within two miles of the site.

The outlet works would consist of a 48-inch diameter steel pipe encased in concrete, placed along the right abutment. Releases would be made directly into the channel of the South Fork Mokelumne River for subsequent diversion through the Mokelumne Ditch.

Reconnaissance cost estimates were made of four different heights of dam at the Railroad Flat site and a cost versus storage capacity curve was drawn. This curve

indicated that a dam of the size contemplated herein would have a capital cost of \$2,200,000 with annual costs of \$107,400.

Possible Supplementary Storage Projects. In order to serve water to the northeast portion of Railroad Flat Service Area, an offstream storage reservoir would have to be constructed on the headwaters of North Fork Calaveras River, as the need arises.

Bingham Reservoir, on North Fork Calaveras River, is suitably located for enlargement at the existing dam or at two other locations downstream from the existing dam. Storage capacities up to 25,000 acre-feet could be realized by construction of a dam at the McCarty site located in the SE 1/4, S35, T6N, R13E, MDB&M, at a streambed elevation of 2,680 feet. Another favorable location exists about 1/2 mile upstream at an approximate streambed elevation of 2,750 feet. Either site would provide sufficient regulatory storage to meet the requirements of the northeast portion of Railroad Flat Service Area and part of the requirement of Jesus Maria Service Area.

The water supply to McCarty Reservoir would be diverted from the South Fork Mokelumne River via the abandoned Clark Ditch, which is suitable for reconstruction. Water diverted through the Clark Ditch would have a deleterious effect on the operation of Railroad Flat Reservoir, as the South Fork Mokelumne River is the major contributor

to the inflow of this latter project. Oversizing of McCarty Reservoir would necessitate importation of water from the Calaveras Project, which in turn would affect the revenue from this project and the supply of water available for diversion to other areas of need along the route of the Calaveras Project. Detailed studies should be made to determine the size of McCarty Reservoir that would yield the most water with the least harmful effect on the Railroad Flat and Calaveras Projects.

Swiss Ranch Project

The Swiss Ranch Project, shown schematically on Figure No. 1, would consist of Swiss Ranch Conduit, Swiss Ranch Reservoir on Jesus Maria Creek, and Emery Conduit. In addition, as the need arises, a conduit from Jesus Maria Creek to the southwest portion of the Railroad Flat Service Area would be constructed. Water would be diverted from the Calaveras Project, after passing through White Pines Afterbay, to Swiss Ranch Reservoir. After reregulation in this reservoir, water would be distributed to the Jesus Maria, Emery, and San Andreas Service Areas, with the above-mentioned provision for future delivery to Railroad Flat Service Area.

Swiss Ranch Conduit. This conduit would divert water from San Antonio Creek in the NW 1/4, S2, T4N, R14E, MDB&M at a streambed elevation of 2,910 feet. The conduit

would be 6.3 miles in length with a capacity of 100 second-feet and would terminate at Swiss Ranch Dam.

Swiss Ranch Dam. The Swiss Ranch Dam would be located on Jesus Maria Creek in the NE 1/4, S19, T5N, R14E, MDB&M at a streambed elevation of approximately 2,530 feet. A topographic map of the dam and reservoir was made in 1961 by the Department of Water Resources at a scale of 1 inch equals 800 feet with a contour interval of 20 feet. Storage capacities of the proposed Swiss Ranch Reservoir at various water surface elevations are presented in Table 35.

TABLE 35
AREAS AND CAPACITIES OF SWISS RANCH RESERVOIR

Water surface elevation, in feet	:	Storage capacity, in acre-feet	:	Area, in acres
2,530	:	0	:	0
2,580	:	100	:	5
2,620	:	400	:	18
2,660	:	1,900	:	54
2,700	:	5,300	:	117
2,740	:	11,700	:	206
2,780	:	22,600	:	310
2,800	:	29,500	:	370

Based on a surficial geologic investigation, the Swiss Ranch damsite is suitable for a rockfill dam with impervious core of the size under consideration in this report. No leakage problem would exist in the reservoir area and silting would be light. About 2.5 miles of oiled road and a secondary power line would require relocation.

As a result of yield studies, geologic investigation, and design criteria, a rockfill dam with impervious core 220 feet in height from streambed to spillway lip with a crest elevation of 2,758 feet was selected for the site. The total volume of fill would be about 1,300,000 cubic yards. Sufficient construction material is available within two miles of the site.

The outlet works would consist of a cut and cover conduit along the left abutment. Gross capacity of the outlet conduit would be 100 second-feet. Provision would be made for stream maintenance releases and for direct release into the Emery Conduit. In addition, provision would be made to siphon water across the channel to the right abutment for release into a distribution ditch to serve the Jesus Maria Service Area.

The Emery Conduit. The Emery Conduit would be a lined trapezoidal canal 3.5 miles in length with a capacity of 60 second-feet. The conduit would convey water to Emery Reservoir on an irrigation schedule for subsequent distribution to the Emery and San Andreas Service Areas.

Estimated capital and annual costs of the various feature of the Swiss Ranch project are presented in Table 36.

TABLE 36

ESTIMATED CAPITAL AND ANNUAL
COSTS OF SWISS RANCH PROJECT
(Based on prices prevailing in 1961)

CAPITAL COSTS	
Swiss Ranch Conduit	\$ 549,000*
<u>Swiss Ranch Dam and Reservoir</u>	
Project construction	2,900,700
Contingencies	<u>570,100</u>
Subtotal	\$3,470,800
Engineering and administration, 15%	<u>517,100</u>
Subtotal	\$3,987,900
Interest during construction at 4%	<u>160,100</u>
Total capital cost of dam	\$4,148,000
Emery Conduit	<u><u>387,000</u></u>
TOTAL CAPITAL COST OF PROJECT	\$5,084,000
ANNUAL COSTS	
Swiss Ranch Conduit	31,000
Swiss Ranch Dam and Reservoir	198,000
Emery Conduit	<u><u>22,000</u></u>
TOTAL ANNUAL COSTS OF PROJECT	251,000

* Includes contingencies, engineering and administration, and interest during construction.

Murphy's-Angel Project

It was contemplated that the Murphy's-Angel Service Area would be served directly from the Calaveras Project. Irrigable lands within the service area are currently served by the Utica Ditch and by direct diversion from local streams. The Murphy's-Angel Project would utilize the existing distribution systems plus construction of minor distribution ditches where needed.

The 2020 requirements of the area total some 3,800 acre-feet which, as stated above, would be diverted from the Calaveras Project after water has passed through the Avery Powerplant. The releases would be made from Avery Afterbay to San Domingo Creek and to Hunter Reservoir on Moran Creek for subsequent diversion to the town of Murphy's through the existing Utica Ditch.

No storage projects were considered necessary in the Murphy's-Angel Service Area at this time. However, it should be noted that several good reservoir sites exist on San Antonio Creek, San Domingo Creek, O'Neil Creek, and South Fork Calaveras River. Preliminary studies indicate that 9,000 acre-feet of yield could be developed on San Antonio and San Domingo Creeks with 7,000 and 5,000 acre-feet of storage on the respective creeks. Preliminary cost studies of these storage projects indicate that the unit cost of developed water would be prohibitive until such time as the

other projects considered herein are amortized. However, potential reservoir sites listed above do indicate a source of water supply that may be developed to meet the requirements of the area beyond the year 2020.

Bear Mountain Project

The Nassau and Bear Mountain Service Areas are so situated as to be financially infeasible of development at the present time. It would be physically possible to transport water to both areas by pipeline and conduit but the unit cost of water would be prohibitive.

Further studies of the possibility of developing local surface and ground water within the two service areas should be made. Salt Springs Valley, within the Bear Mountain Service Area, could be served by pumping from Salt Springs Reservoir. Water from this reservoir could be lifted approximately 90 feet and released into Littlejohns Creek to serve the southern portion of the area. Under this plan, the present users of water from Salt Springs Reservoir would be served from the New Melones Canal under an exchange agreement.

Development of North Fork of Stanislaus River Basin as Proposed by Calaveras County Water District

Alternative plans for the development of the waters of the North Fork Stanislaus River have been proposed by two

local agencies; the Calaveras County Water District, and the Stanislaus River Basin Group. Although the plans proposed by these agencies have not been formally reviewed by the department, they are presented in this and the following sections as alternative possibilities.

Project Features. The North Fork area development plan includes four major dams and reservoirs, three diversion dams, four powerplants totaling 321,000 kilowatts installed capacity, and a series of conduits and related control works, all of which would regulate the flow of the North Fork of the Stanislaus River and its tributaries for consumptive irrigation and domestic uses and for power generation. This development plan is shown on Plate 13, "Alternative Plans for Development of North Fork Stanislaus River."

North Fork Diversion Dam and Tunnel. The proposed diversion structure would be located on the Upper North Fork Stanislaus River immediately below its junction with Silver Creek. It would serve to divert water from the North Fork, through a tunnel, to storage in an enlarged Spicer Meadows Reservoir. Both the diversion dam and tunnel would be located in granitic-type rock.

Spicer Meadows Dam and Reservoir. Spicer Meadows would be located immediately downstream from the existing concrete gravity dam on Highland Creek, which is a tributary

of the North Fork Stanislaus River. The existing concrete dam would be used as the upstream toe of the proposed new structure.

Spicer Meadows Reservoir with a capacity of 130,000 acre-feet at maximum water surface elevation of 6,580 feet would regulate the flows in both Highland Creek and the diversions from the North Fork Stanislaus River above Silver Creek.

Spicer Tunnel and Penstock. The Spicer Tunnel and Penstock would convey the water from the Spicer Meadows Reservoir to the Sand Flat Powerplant. The tunnel and penstock, 12 feet and 6 feet in diameter and 21,300 feet and 1,290 feet in length respectively, would have a maximum capacity of 565 cubic feet per second.

Sand Flat Powerplant. This powerplant would be located at the upper end of Ganns Reservoir on the North Fork Stanislaus River. The powerplant is planned to be an indoor, unattended plant. The installation would consist of a single impulse wheel turbine driving a generator with a maximum capacity of 25,000 kilowatts. Design is based on a flow of 565 cubic feet per second at 600-foot head. Maximum static head is 741 feet.

Ganns Dam and Reservoir. Ganns Dam would be located on the North Fork Stanislaus River, approximately 3/4 mile below its confluence with Highland Creek. The reservoir would

extend into both Highland Creek and the North Fork Stanislaus River and would serve to regulate flows below the North Fork Diversion and Spicer Meadows Reservoir as well as reregulate the flows from the Sand Flat Powerplant. The dam would have a maximum height of 380 feet. An ungated overflow spillway with a capacity of 20,000 cubic feet per second is contemplated in the right abutment. The reservoir, at maximum water surface elevation of 5,828 feet, would provide a storage capacity of 60,000 acre-feet.

Ganns Tunnel and Penstock. A tunnel, slightly in excess of 10 miles in length, would convey the water from Ganns Reservoir to a penstock leading to the Boards Crossing Powerplant. The maximum capacity of the tunnel would be 1,000 cubic feet per second. The tunnel, with the intake invert elevation of 5,520 feet at Ganns Reservoir, would be located in the granite ridge along the north side of the river. The steel penstock, 10 feet in diameter and 3,000 feet in length, would be located on the surface leading to the powerplant. Provision can be included at the end of the tunnel near the beginning of the penstock, for an outlet for the Ebbetts Pass Road domestic water system.

Boards Crossing Powerplant. The powerplant at the end of the Ganns Tunnel and Penstock would be an 85,000 kilowatt installation consisting of two impulse turbines generating with 1,000 cubic feet per second flow under a maximum

static head of 1,683 feet. The tailrace from this plant would terminate in the upper end of the Big Trees Reservoir at this location. The plant is planned to be an above-ground installation on the right bank of the river.

Big Trees Dam and Reservoir. Big Trees Dam would be located approximately 9,200 feet downstream of the Boards Crossing Bridge on the North Fork Stanislaus River. It would be a 400-foot high rockfill structure with a sloping impervious core. The total storage capacity provided is 162,000 acre-feet. A portion of the water to be diverted for supplemental irrigation water supply in Calaveras County may be stored in this reservoir.

Upper Beaver Diversion. This structure would be a 60-foot high earth dam constructed on Beaver Creek at a point approximately opposite Big Trees Reservoir. All flows in Beaver Creek from 15 second-feet to 800 second-feet would be diverted into Big Trees Reservoir.

A 2,800-foot canal of 800 second-feet capacity leading from the diversion dam and through a saddle in the ridge between the North Fork Stanislaus River and Beaver Creek is planned to transport the diverted water into Big Trees Reservoir. Flows in Beaver Creek in excess of this capacity would be released into the stream channel of the diversion structure. Storage behind the dam would be approximately 600 acre-feet.

Big Trees Tunnel. This tunnel would be a 16-foot horseshoe section, approximately 2 miles in length. The designed capacity is 1,300 second-feet. The steel penstock from the end of the tunnel would be 6 feet in diameter.

Big Trees Powerplant. This powerplant would be a surface structure on the right bank of the North Fork Stanislaus River at the upper end of Squaw Hollow Reservoir approximately at the location of the existing Pacific Gas and Electric Company Utica System diversion works. The installation would consist of one Francis turbine driving a generator with a maximum capacity of 50,000 kilowatts. The static head is 776 feet. Squaw Hollow Dam would regulate the tailwater elevation for this plant.

Squaw Hollow Dam and Reservoir. The site for the Squaw Hollow Dam is approximately one mile downstream from the existing diversion works of the Pacific Gas and Electric Company Utica System. The dam would be a concrete arch 130 feet high, with a center overflow spillway of 30,000 second-feet. The capacity of the reservoir behind the dam would be approximately 2,000 acre-feet. The principal purpose of this dam and reservoir is for diversion to the Murphys Tunnel, regulation of inflows to the North Fork Stanislaus River between Big Trees Dam and Squaw Hollow Reservoir, and as an afterbay for the Big Trees Powerplant.

Lower Beaver Creek Diversion. Pacific Gas and Electric Company has a diversion structure on Beaver Creek approximately opposite their diversion works for the Utica System on the North Fork Stanislaus River. Water from Beaver Creek is diverted to the Stanislaus through a tunnel in the ridge between the two streams. It is planned to enlarge these two structures for diversion of the streamflow from 15 second-feet up to 400 second-feet to the Squaw Hollow Reservoir. Flows passing the Upper Beaver Creek Diversion and inflows between the two structures, less releases required for fish, would be diverted at this point.

Murphys Tunnel and Penstock. The intake for this tunnel would be at Squaw Hollow Reservoir with invert at elevation 3,280. The tunnel would be located in the ridge along the right side of the North Fork Stanislaus River, daylighting at a point approximately 15,000 feet after crossing Mill Creek. A steel penstock would extend on the surface from the end of the tunnel to the Collierville Powerplant at Clarks Flat. The tunnel and penstock are designed for 1,000 second-feet. A riser would be provided in the tunnel approximately 29,000 feet below the intake to discharge the water supply for irrigation into the central Calaveras County area. This service outlet is planned to be for 400 second-feet.

Collierville Powerplant. This powerplant would be at the terminus of the Murphys Tunnel and Penstock at Clarks Flat below the confluence of the North and Middle Forks Stanislaus River. The installation would consist of two impulse turbines driving generating units with a total installed capacity of 161,000 kilowatts. The design is for a flow of 1,000 second-feet at a static head of 2,255 feet. The water would be returned to the Stanislaus River below the powerplant.

Project Accomplishments

As presented by the Calaveras County Water District, the North Fork area development plan would provide 21,000 kilowatts of installed power generating capacity, 54,000 acre-feet of storage, and an annual diversion of 5,000 acre-feet for consumptive use in the Main Stream and Tributary Units.

Project Costs

The total capital cost of the North Fork area development plan has been estimated for the district in the amount of \$122,577,000. Total annual costs were estimated to be \$6,955,000, resulting in a net annual income of \$869,000. A benefit-cost ratio was developed.

Development of North Fork Stanislaus
River Basin as Proposed by the
Stanislaus River Basin Group

The Stanislaus River Basin Group is composed of the Calaveras County Water District, Tuolumne County Water District No. 2, Oakdale Irrigation District, and South San Joaquin Irrigation District. As stated previously, no formal review of this plan was made by the department in the current investigation.

Project Features

The Stanislaus River Basin Group (SRBG) plan (Plate 13) is similar to the one proposed for the Calaveras County Water District which is discussed in the preceding section of this report. However, the number of project units and scope of development would be considerably reduced as compared to the latter proposal. Four storage reservoirs are proposed to provide a total of 294,000 acre-feet of storage. Two powerplants are planned with a total installed capacity of 165,000 kilowatts. Two diversion dams and two conduits would also be required under the plan. As in the case of the Calaveras County Water District Plan, no review has been made as to the advantages of this proposal relative to other possible developments. The following project features proposed under the SRBG plan are identical to corresponding units under the CCWD plan:

Spicer Meadow Dam and Reservoir
Big Trees Dam and Reservoir
Upper Beaver Diversion Dam and Tunnel
Big Trees Tunnel
Big Trees Powerplant
Squaw Hollow Dam and Reservoir
Lower Beaver Diversion Dam and Tunnel
Murphys Tunnel and Penstock

The remaining feature, Collierville Powerplant, would provide an installed capacity of 115,000 kilowatts as compared to 161,000 kilowatts under the CCWD plan.

Project Accomplishments

The SRBG plan would provide an installed capacity of 165,000 kilowatts of power generation. Storage capacity in two reservoirs would be 132,000 acre-feet.

Project Costs

The capital costs of the North Fork area development have been estimated as \$52,533,000. The annual cost, including replacement cost, is shown as \$500,000. Annual power revenues would be approximately \$4,432,000. No benefit-cost analysis was developed.

New Melones Project

The New Melones Project was authorized by the Flood Control Act of 1944, Public Law 534, Seventy-eighth Congress, Second Session, and modified by the Flood Control Act of 1962, Public Law 87-874, Eighty-seventh Congress, Second Session. Public Law 87-874 reads in part as follows:

"The New Melones project, Stanislaus River, California, authorized by the Flood Control Act approved December 22, 1944 (58 Stat. 887), is hereby modified substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 453, Eighty-seventh Congress, at an estimated cost of \$113,717,00: Provided, That upon completion of construction of the dam and powerplant by the Corps of Engineers, the project shall become an integral part of the Central Valley project and be operated and maintained by the Secretary of the Interior pursuant to the Federal reclamation laws, except that the flood control operation of the project shall be in accordance with the rules and regulations prescribed by the Secretary of the Army: Provided further, That the Stanislaus River Channel, from Goodwin Dam to the San Joaquin River, shall be maintained by the Secretary of the Army to a capacity of at least eight thousand cubic feet per second subject to the condition that responsible local interests agree to maintain private levees and to prevent encroachment on the existing channel and floodway between the levees: Provided further, That before initiating any diversions of water from the Stanislaus River Basin in connection with the operation of the Central Valley project, the Secretary of the Interior shall determine the quantity of water required to satisfy all existing and anticipated future needs within that basin and the diversions shall at all times be subordinate to the quantities so determined: Provided further, That the Secretary of the Army adopt appropriate measures to insure the preservation and propagation of fish and wildlife in the New Melones project and shall allocate to the preservation and propagation of fish and wildlife, as provided in the Act of August 14, 1946 (60 Stat. 1080), an appropriate share of the cost of constructing the Stanislaus River diversion and of operating and maintaining the same: Provided further, That the Secretary of the Army, in connection with the New Melones project, construct basic public recreation facilities, acquire land necessary for that purpose, the cost of constructing such facilities and acquiring such lands to be nonreimbursable and nonreturnable: Provided further, That contracts for the sale and delivery

of the additional electric energy available from the Central Valley project power system as a result of the construction of the plants herein authorized and their integration with that system shall be made in accordance with preferences expressed in the Federal reclamation laws except that a first preference, to the extent as needed and fixed by the Secretary of the Interior, but not to exceed 25 per centum of such additional energy, shall be given, under reclamation law, to preference customers in Tuolumne and Calaveras Counties, California, for use in that county, who are ready, able, and willing, within twelve months after notice of availability by the Secretary of the Interior, to enter into contracts for the energy and that Tuolumne and Calaveras County preference customers may exercise their option in the same date in each successive fifth year providing written notice of their intention to use the energy is given to the Secretary not less than eighteen months prior to said dates: And provided further, That the Secretary of the Army give consideration during the preconstruction planning for the New Melones project to the advisability of including storage for the regulation of streamflow for the purpose of downstream water quality control . . ."

Funds for advanced planning of the New Melones Project by the Corps of Engineers, United States Army, are included in the current (1963) budget being considered by the Congress.

As part of the process of obtaining modification of the authorization of the New Melones Project by Congress, the office of the Chief of Engineers, U. S. Department of the Army, on January 4, 1962, transmitted to the Department of Water Resources its proposed report entitled "Review Report for Flood Control on New Melones Project, Stanislaus

River, California," for review and comment in accordance with the provisions of Public Law 537, 78th Congress, and Public Law 85-624. Subsequently, the department transmitted its comments on the New Melones Project in its report entitled "Views and Recommendations of State of California on Review Report for Flood Control on New Melones Project, Stanislaus River, California," April 1962. This report is included herein in the appendices.

The New Melones Project, including a possible conduit to serve to Bachelor Service Area is shown on Plate 7.

The most important conclusions in the department's comments on the New Melones Project relative to the Calaveras area include:

1. To be in conformance with the objectives of The California Water Plan, the New Melones Project should be subject to the rights of upstream areas dependent upon waters of the Stanislaus River and to the use of such water as may be required for the future development of such areas.

2. The New Melones Project (as formulated in the report that was reviewed) does not adequately provide for the water needs of Calaveras and Tuolumne Counties and the Bachelor Service Area.

As stated in Appendix A, the recommendations that were included in the department's comments are as follows:

"It is recommended that the proposed New Melones Project on the Stanislaus River be authorized by the Congress at an early date for construction and operation by the federal government; provided that:

1. Recognition be given to the right of the upstream areas dependent upon waters of the Stanislaus River to develop and utilize water required for the future development of such areas.

2. Water be released downstream for fisheries purposes and land be acquired for recreation and wildlife as previously recommended herein.

3. Studies be authorized to develop the full potential of the North Fork of Stanislaus River, including formulation of additional features of the New Melones Project designed to serve 30,000 acre-feet of water each year initially increasing to 50,000 acre-feet by the year 2015, for use in upper Calaveras County. Further, that the Sonora-Keystone Investigation of the Bureau of Reclamation be programmed to formulate features of the New Melones Project to provide 30,000 acre-feet each year to the Sonora-Keystone area.

4. The Bachelor Service Area be served water from the New Melones Project or by an exchange from the Folsom South Canal."

It is noted that there are points of difference in the provisions of Public Law 87-874 and the foregoing recommendations, with regard to the reservation of water for local use. Public Law 87-874 states in effect that diversions from the Stanislaus River Basin shall at all times be subordinate to the quantities needed to satisfy the needs of the basin. The department's recommendation is broader in that reservations would be made to serve the entire needs of Calaveras County. Also, that a means should be developed to serve the Bachelor Service Area either from New Melones Reservoir or from Folsom South Canal.

The proposed additional features of the New Melones Project that would serve upper areas of Calaveras County were previously described in this chapter. They include: (1) the Calaveras Project, (2) the West Point Project, (3) the Railroad Flat Project, and (4) the Swiss Ranch Project. The projects are described in detail in other sections of this chapter.

New Hogan Project

Construction of New Hogan Dam and Reservoir was authorized as a portion of the Littlejohn Creek and Calaveras River Stream Groups Project by the Flood Control Act of 1944, Public Law 534, Seventy-eight Congress, Second Session. Public Law 534 reads in part as follows:

"The plan of improvement for flood control and other purposes on the Calaveras River and Littlejohn Creek and tributaries, California is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 545, Seventy-eighth Congress, second session, at an estimated cost of \$3,868,200."

New Hogan Dam, now under construction, is a rock-fill dam with an impervious earth core and a maximum height of about 200 feet, located on the Calaveras River, about 28 miles northeast of Stockton, just downstream from the former Hogan Dam. New Hogan Reservoir will have a gross storage capacity of 325,000 acre-feet for flood control,

irrigation, and other water conservation purposes. The dam and reservoir will produce an estimated new average annual yield of water of approximately 38,000 acre-feet and a total yield of about 71,800 acre-feet per year including the yield of the former Hogan Reservoir. The dam was about 65 percent completed in March 1963, and is scheduled for completion during June 1964.

Early construction of New Hogan Project was made possible by a contract between the U.S. Bureau of Reclamation and the Department of Water Resources to guarantee the repayment of the conservation portion of the project costs. To follow the older practice of first selling the water, and then beginning construction, would have delayed construction for some indefinite time. By starting construction earlier, much needed flood control will be provided in the near future.

Under the terms of the contract, the Bureau will have seven years after the project is completed in which to negotiate contracts for local use of the water; and to the extent that it succeeds in doing so, the State's share of the cost will be reduced proportionately. If the Bureau is completely successful, the State will no longer be obligated for repayment of these project costs. After the seven-year period, the State will have the right to contract with entities for that portion of the storage space or water service not obligated by Bureau contracts.

As a part of the process of funding the authorized project, the U.S. Army, Corps of Engineers, prepared "Report

on Preliminary Cost Allocation Studies, New Hogan Project, Calaveras River, California," and on February 25, 1958, the Department of Water Resources transmitted to the Sacramento District of the Corps of Engineers comments of the State of California regarding the report. This letter is included in the appendix of this report.

The New Hogan Project, including a possible conduit to serve the Hogan Service Area, is shown on Plate 7.

Important portions of the department's comments on the New Hogan Project relative to the Calaveras area include:

"1. There is a need for the project. Construction of New Hogan Reservoir to a capacity of 325,000 acre-feet would provide flood protection needed now in the Stockton area and would also provide for full development of Calaveras River for conservation purposes.

2. Water from New Hogan Reservoir could be utilized temporarily by Stockton and East San Joaquin Water Conservation District but ultimately the entire yield of the reservoir would be required, and in the opinion of the department should be used, to serve the Bear Creek* and Hogan Service Areas.

3. Department estimates indicate that under full development the needs of the Bear Creek* and Hogan Service Areas will exceed the yield from New Hogan Reservoir. When the Folsom South Canal is constructed, all the physical facilities needed to provide direct service to the Stockton and East San Joaquin Water Conservation District, as well as to the Bear Creek and Hogan Service Areas, will exist."

*The area included in the former Bear Creek Service Area is currently included in the Hogan Service Area.

CHAPTER VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The rapid expansion of population in California since World War II and the corresponding increase in water requirements, have resulted in a need for an accelerated program of water resource development. The Legislature, realizing the urgency of this need, has provided funds for planning a coordinated statewide development of water resources.

The objective of the Calaveras Investigation was to formulate plans for the development of the water resources of the Mokelumne, Calaveras, and Stanislaus Rivers. During the course of the investigation, the federal government has started construction of New Hogan Dam on the Calaveras River and has completed planning for New Melones Dam on the Stanislaus River and the Folsom South Canal. These projects will provide for the needs of the San Joaquin Valley and lower foothill lands.

Summary

The area of investigation extends approximately from the Mokelumne River southward to the Stanislaus River and from the western reaches of the Delta eastward to Alpine

County. It encompasses all of Calaveras County and a portion of San Joaquin and Stanislaus Counties.

The topography varies from flat terrain on the valley floor through gently rolling hills in the mid-regions to rugged slopes and deeply incised canyons in the eastern area. The climate of the valley is characterized by hot, dry summers and mild winters; and, as the elevations increase to the east, the summers become milder and the winters more severe. The length of the growing season varies from 270 to 135 days. Four general soil types are found in the area: (1) deep, well-drained fertile soils on the valley floor, (2) coarse-to-medium textured soils in the foothill area, (3) medium textured soils with underlying layers of hardpan, and (4) relatively shallow weathered-rock types in the highlands. Geologically, the older rocks in the area are resistant pre-Tertiary metamorphic and intrusive igneous rocks, locally of unequal strength and complex structure. This bedrock series is overlain by essentially undeformed geologic materials of Tertiary age and younger.

The earliest development of the Calaveras area started with a French trading post near Stockton in 1830. The gold mining era--from 1848 to 1875--provided impetus to the growth of the area; and development in the valley took place almost as rapidly in order to satisfy the demand of the mining regions for beef and produce. A period of

adjustment to a reduced level of mining activity and local agricultural enterprise has followed. The water supply development history has closely paralleled the economic history of the Calaveras area. The first water supply projects served mining needs; and, as these needs were fulfilled, the emphasis shifted to providing water supplies for agricultural purposes. Today, the major economic activity on the valley floor portions of the area is agriculture. In Calaveras County, the major sources of income are mining, lumbering, forest products industries, livestock grazing, agriculture, commercial establishments, recreation, and the production of hydroelectric energy. The chief beneficiaries of water resources development in the Calaveras area would be the operators of agricultural and grazing lands along the foothills of San Joaquin and Stanislaus Counties between the Mokelumne and Stanislaus Rivers, since these areas are now dry-farmed.

Water Supply

The water supply of the Calaveras area originates as direct precipitation, surface and subsurface inflow, and water pumped from the Delta to serve irrigated lands in the valley. A portion of the water supply is used within the area of investigation, but most of it either drains from the area by way of the Mokelumne, Calaveras, and Stanislaus

Rivers or is retained in storage reservoirs for use in remote areas. The major portion of surface runoff occurs during late spring and early summer months from the melting of the Sierra Nevada snowpack. Both precipitation and runoff fluctuate widely from year to year. Ground water, replenished by surface runoff, is the principal source of water for irrigation in the San Joaquin Valley. Ground water is not a significant source of supply for Calaveras County.

Precipitation

Precipitation on the Calaveras area is derived almost entirely from easterly moving storms that originate over the North Pacific. This precipitation is generally light on the valley floor and lower foothill areas and moderately heavy in the highlands near the crest of the Sierra Nevada.

Runoff

Runoff from rainfall and snowmelt in the Mokelumne, Calaveras, and Stanislaus River Basins constitutes the only significant sources of water available for development for use in the foothill and mountainous portions of the Calaveras area. Although extensive development of this runoff has taken place for use in other areas, substantial portions are still unregulated and wastes from the area.

Runoff Characteristics. Runoff from the Mokelumne

and Stanislaus River Basins is derived, for the most part, from snowmelt. As a result, peak flows of these streams are reached in spring and early summer months, and low flows occur during late summer months. The maximum elevations of the Calaveras River Basin, however, are considerably lower, and snowmelt does not contribute significantly to the runoff of this stream. Consequently, the monthly runoff pattern for the Calaveras River follows closely the monthly pattern of precipitation on the basin.

Flow of the Mokelumne River above the valley floor is impaired by Pardee, Salt Springs, and Bear River Reservoirs. The impairments to the flow of the Calaveras River above Hogan Reservoir are negligible. The Stanislaus River flow is impaired by developments of the Pacific Gas and Electric Company and by the Oakdale and South San Joaquin Irrigation Districts.

Records for the Mokelumne River show that the maximum annual discharge was 1,500,000 acre-feet, and the maximum instantaneous rate was 28,800 second-feet. During July and August of 1934, the flow dropped to zero at times. The maximum annual discharge for the Calaveras River was 539,000 acre-feet, compared to a minimum of 13,400 acre-feet. The maximum instantaneous flow rate was 50,000 second-feet and the flow drops to zero during the late

summer months of most years. The maximum recorded annual flow for the Stanislaus River totaled 2,780,000 acre-feet, compared to a minimum of 280,000 acre-feet. Instantaneous flow rates were 64,500 second-feet, reducing to less than one second-foot on many occasions.

Imported and Exported Water. Water is exported from the Mokelumne River Basin to the East Bay Municipal Utility District by means of a conveyance system with a capacity of 310 second-feet. The Pacific Gas and Electric Company operates the Amador Canal to divert Mokelumne River water for irrigation and domestic use in Amador County. Water is diverted from the South Fork of the Stanislaus River through the Lyons-Phoenix System by the Pacific Gas and Electric Company for energy generation and consumptive use near Sonora. The Pacific Gas and Electric System operates the Utica Ditch System which diverts water from the North Fork of the Stanislaus River for the generation of energy and consumptive use in Calaveras County.

Ground Water

Ground water is not a significant source of water supplies in the foothill and mountainous areas. However, the San Joaquin Valley portion of the Calaveras area is underlain by water-bearing materials of considerable storage capacity.

The San Joaquin Valley portion of the area of investigation consists of the Valley Unit and portions of the Main Stream Unit at the lower elevations. The development of water resources for this unit is discussed in detail in Bulletin No. 11, "San Joaquin County Investigation," and the Valley Unit of this report encompasses the following ground water units as discussed in Bulletin No. 11: Eastern Mokelumne Unit, Western Mokelumne Unit, Calaveras Unit, and Littlejohns Unit. The net seasonal extractions from these units as reported in Bulletin No. 11 was about 363,000 acre-feet. The total mean annual consumptive use of water at the present time is estimated to be 837,000 acre-feet. The estimated probable maximum consumptive use of applied water would be 1,122,000 acre-feet. The estimated safe yield of the ground water basins is about 311,000 acre-feet.

Water Quality

The surface waters of Calaveras area are of excellent mineral quality and are well suited to all beneficial uses. Ground waters of the area were also generally of excellent mineral quality; however, wells located in areas of excessive drawdown may be affected where the ground water basin is not adequately replenished.

Land and Water Use

The present water supply development of the Calaveras area includes surface supply for the generation of energy and for recreational, domestic, and limited irrigation purposes. On the valley floor, ground water has been extensively developed for irrigation purposes. For purposes of this report, the area of investigation has been divided into major geographical units and these units are further subdivided into subunits which represent logical service areas.

Units of the Investigative Area. The major units are delineated on Plate 2 and are called the Valley, Main Stream, and Tributary Units. The latter two units have been subdivided into service areas as shown on Plate 2A.

Land Use

Projections of future water requirements are largely based upon future projections of the use of the land. Patterns of land use that prevailed during 1958 and 1959 were determined for the Calaveras area except those areas of the Valley Unit which lie to the west of the proposed Folsom South Canal. Previous land use studies for these areas were conducted by the Department of Water Resources and the results were presented in Bulletin No. 11, "San Joaquin County Investigation."

Present Land Use. Present land use as determined in 1958 and 1959 by field surveys is shown on Plate 6, "Classification of Present and Potential Land Use." The predominant current use of lands requiring water service is for irrigated agriculture.

Potential Patterns of Land Use. An estimate of the potential land use pattern was prepared and is shown on Plate 6. For purposes of economic analysis, the growth of land use development was predicted by decades to the mid-decade year 2015. Several basic assumptions were necessary in this process, of which the most important are: (1) an additional water supply to the Tributary Unit would be limited by those uses which could sustain a maximum cost of \$5-10 per acre-foot, with an annual upper limit of 30,000 acre-feet; and, (2) an additional supply to the Main Stream Unit could be developed for use capable of sustaining the same water costs, with no upper limit regarding annual supply. Lands in the Valley Unit are presently under intensive irrigation. Future expansion of irrigation requirements in this unit would be supplied with water from the proposed Folsom South Canal.

Present Water Use and Requirements. Of the presently developed waters of the Calaveras area in the Tributary and Main Stream Units, only about 41,170 acre-feet per year are consumptively used. Water requirements

include the water use plus allowances for seepage losses. The present annual estimated water requirements for the two units is 57,800 acre-feet.

Future Water Use and Requirements. Based upon the projected level of urban, suburban, agricultural, and recreational development as projected by the land use studies, the mean annual consumptive use of applied water in the year 2020 is estimated to be 212,500 acre-feet for the Tributary and Main Stream Units. The corresponding water requirements are estimated to be 300,400 acre-feet. Since approximately 39,100 acre-feet of the present supply is considered to be available in the future, the balance of 261,300 acre-feet per season represents the project water required by the year 2020.

Water Rights

Conflicting water rights applications for appropriation of water from the North Fork of the Stanislaus River have been filed in the period since 1947. The State Water Rights Board, by Decision D-1114 adopted in March of 1963, granted certain of the permits and denied all others. Several state applications are involved and it may be necessary for the California Water Commission to hold hearings on these applications later.

In order to determine the extent of availability of unappropriated water on the Mokelumne River, it appears that hearings will be required by the State Water Rights District. If developments were undertaken under State Application 5648, it may be necessary for the California Water Commission to conduct a hearing.

In order to determine the extent of availability of unappropriated water to development in the upper Calaveras River watershed, the State Water Rights Board held hearings on several applications in April of 1963 and a decision is anticipated later in that year. The California Water Commission, on May 4, 1962, granted a release from priority of Application 5648 at the New Hogan Dam in favor of the applications of the Calaveras County Water District for its upper Calaveras River development.

Plans for Water Development

The growth and enhancement of the economy of the Calaveras area will require the development of adequate water supplies at costs that future users will be able to pay. In the Tributary and Main Stream Units, present curtailments of water use in critical periods result in restrictions to further economic development. In the Valley

Unit, present water demands are met by overdrawing ground water supplies. This overdraft, if continued, will result in increased pumping costs and a threat of degradation of the mineral quality of the water. During the late spring and early summer months, surplus flows exist in the streams of the area. These flows, if properly controlled and distributed, could meet future water requirements of the upper Calaveras area.

Water Conservation Possibilities

Several possible means of providing additional water supplies to the Calaveras area were considered during this investigation, as follows: (1) direct diversion of streamflow, (2) increased ground water development, and (3) further development of unregulated surface waters of the Calaveras area.

Direct Diversion of Unregulated Streamflow. The possibility of supplementing existing water supplies by direct diversions from the Mokelumne, Calaveras, and Stanislaus Rivers is extremely limited. This is true because of the intermittent runoff characteristics of the small streams and fluctuations of monthly and annual runoff in all streams. The entire dry-season flow of many streams is already subject to existing water rights. For these reasons, the direct diversion from streams is not considered to be a practicable means for development additional water supplies.

Increased Ground Water Development. The possibility

for developing additional supplies for use within the area of investigation from further ground water development is not feasible. As stated in foregoing sections, the ground water basins in the Valley Unit are currently subject to dangerous overdrafts, and further increase would only tend to aggravate this condition. No ground water aquifers of any significant size exist in the higher reaches of the Main Stream Unit or in the Tributary Unit. Consequently, the future development of ground water supplies is not considered to be a feasible means of providing additional water supplies.

Future Development of Unregulated Waters of the

Calaveras Area. The possibility of developing, in storage reservoirs, unregulated waters of the Calaveras area appears to be the most practical solution for providing additional water supplies for use in the Tributary and Main Stream Units. As shown on Plate 7, it is contemplated that the future requirements of the major units of the area of investigation would be satisfied in the following manner:

1. Tributary Unit. Small water conservation projects would be constructed in upper Calaveras County to provide for local consumptive needs. To supplement this source of supply, a multipurpose project would be constructed

on the North Fork of the Stanislaus River which would provide water for importation into Calaveras County and would provide revenue through the generation of power.

2. Main Stream Unit. Lands within this unit would be served from the yield of New Melones Reservoir and New Hogan Reservoir, supplemented by pumping from the proposed Folsom South Canal.

3. Valley Unit. Irrigated and irrigable lands on the valley floor would continue to be served by ground water supplies, supplemented by direct diversion from the proposed Folsom South Canal.

The overall plan of development is shown in schematic form in Figure 1, "Schematic Flow Diagram of Water Supply Development, Calaveras Area."

Calaveras Project. The Calaveras Project, shown on Plate 8, would develop a firm water supply of about 106,000 acre-feet per year. Provisions would be made for diverting approximately 16,000 acre-feet of this firm supply plus an annual average excess supply of 22,100 acre-feet, into the interior regions of Calaveras County. The remaining 90,000 acre-feet of diversion would be returned to the North Fork of the Stanislaus River. Three powerplants are planned

with a total installed capacity of 109,300 kw and an average annual production of energy totaling 350,000,000 kwh.

A brief description of the Calaveras Project follows. A tunnel connecting Union Reservoir with Spicer Meadow Reservoir would be enlarged by the construction of a new dam. This reservoir would regulate the runoff from the upper North Fork drainage area to provide the additional yield required for the project. Regulated discharges from the reservoir would be conveyed by Highland Creek and the North Fork of the Stanislaus River to the proposed Ganns Diversion Dam. Diversions would be made from this location through a tunnel and conduit to a system of three powerplants and secondary diversion points which would provide for supplementing water supplies to Calaveras County.

The total capital cost of all project facilities, including recreational features, is estimated to be \$47,678,500. The present worth of a 50-year annual equivalent repayment cost series, including an item for taxes foregone for the powerplants, would be \$81,961,700. Primary tangible benefits attributable to the project are derived from power generation and recreation, and have been estimated to be \$89,161,300. The benefit-cost ratio, as shown on Table 26, is estimated to be 1.12:1. It should be noted that no benefits from irrigation, municipal, or domestic

water supply were considered attributable to the project. Hence for the purposes of this reconnaissance report, the water available for diversion to Calaveras County could be considered to be cost-free at the point of diversion from the project system.

Local Development Plans. In order to meet the future water supply requirements of the Tributary Unit, several storage projects are contemplated for the purpose of regulating more effectively the surface runoff that presently wastes and to reregulate such water supplies as may be imported into the area from the North Fork of the Stanislaus River via the Calaveras Project. These projects are shown on Plate 11, "Plan of Possible Local Development Projects," and in schematic form in Figure 1. Because the original estimates of land use, and water requirements derived therefrom, were based on assumed maximum water costs of \$5-10 per acre-foot, the local development plans discussed herein do not represent formulated projects. However, these facilities are believed to afford the best possibilities for future, more detailed studies toward the development of water supplies for the various service areas of the Tributary Unit.

The West Point Project would consist of three reservoirs in or adjacent to the West Point Service Area. Schaad Reservoir, on the Middle Fork of the Mokelumne

River, would be enlarged; and new reservoirs that would be constructed are Campground Reservoir, on Forest Creek, and Hunter Creek Reservoir. Two conduits would also be required, one from Forest Creek to Hunter Creek, and the other from Hunter Creek to Bear Creek. The conjunctive regulation provided by these reservoirs would provide a yield of 7,000 acre-feet annually, which closely approximates the future water requirements of the West Point Service Area. The estimated capital costs for this project is \$5,281,000.

The Railroad Flat Project would consist of Railroad Flat Reservoir on the South Fork of the Mokelumne River and would contemplate use of the existing Mokelumne Ditch and construction of additional distribution ditches in the Mokelumne Hill and Paloma areas. The southwest portion of the Railroad Flat Service Area would be the principal area served by this reservoir. Of the year 2020 water requirements of 16,000 acre-feet predicted, 12,000 acre-feet would be supplied by the Railroad Flat Project and the remaining 4,000 acre-feet would come from Swiss Ranch Reservoir. The estimated capital costs of this project is estimated to be \$2,200,000.

The Swiss Ranch Project would consist of the Swiss Ranch Reservoir on Jesus Maria Creek, Swiss Ranch Conduit and Emery Conduit. In addition, as the need

arises, a conduit from Jesus Maria Creek to the southwestern part of the Railroad Flat Service Area is contemplated. Water would be imported to this reservoir from the Calaveras Project; and, after reregulation, it would be distributed to Jesus Maria, Emery, and San Andreas Service Areas. The estimated capital costs of this project are \$5,084,000.

New Melones Canal. It is contemplated that the New Melones Project, as proposed by the U.S. Army Corps of Engineers, would include a New Melones Canal for delivery of water to the Bachelor Service Area. New Melones Canal would extend from Goodwin Reservoir on the Stanislaus River in a northwesterly direction to the North Fork of Duck Creek. Several small reservoirs would be constructed along the way and would be utilized both for the storage of water and for the propagation of warmwater fishes.

The Hogan Conduit. The Hogan Service Area would be served with water from the New Hogan Project currently under construction by the U.S. Army Corps of Engineers. The conduit would extend from New Hogan Reservoir westerly for about 23 miles through the Hogan Service Area. Since the supplemental yield of New Hogan Reservoir is estimated to be 38,000 acre-feet, compared to the year 2020 requirement for the Hogan Service Area of 65,000 acre-feet, it is contemplated that water service deficiencies will be met by pumped supplies from Folsom South Canal.

Development of North Fork Stanislaus River as Proposed by
Calaveras County Water District

The Calaveras County Water District has completed a master plan for the local development of water resources within Calaveras County. Only that part of the district plan which deals with the North Fork Stanislaus River is discussed herein.

The North Fork Development Plan consists of four major dams and reservoirs, three diversion dams, four power-plants having a total installed capacity of 321,000 kw, and a series of connecting conduits and related works. This plan is shown on Plate 13, "Alternative North Fork Stanislaus Development Plans." The estimated capital costs of this plan were estimated by the district to be \$122,577,000.

Development of North Fork Stanislaus River as Proposed by
the Stanislaus River Basin Group

The Stanislaus River Basin Group is composed of the Calaveras County Water District, Tuolumne County Water District No. 2, Oakdale Irrigation District, and South San Joaquin Irrigation District.

The North Fork Development Plan as proposed by the group includes many of the same features as the plan proposed by the Calaveras County Water District previously discussed; however, the number of project units has been reduced. Four storage reservoirs are proposed which would

provide a total capacity of 294,000 acre-feet, two power-plants with a combined capacity of 165,000 kw, two diversion dams and two conduits are included in this plan, which is also shown on Plate 13. The capital cost of this project has been estimated by the Stanislaus River Basin Group to be \$52,533,000.

Conclusions

1. The future growth of the Calaveras Area is largely dependent upon the development of additional water supplies at a cost within the payment capacity of the prospective users.

2. In the Valley Unit current water requirements are satisfied at the expense of excessive pumping of ground water, thereby causing progressive lowering of the ground water level. Supplemental water supplies for this unit will be required in the future in order to alleviate the ground water overdraft and to permit further development of the area. The logical source of additional water would be the Folsom South Canal as proposed by the United States Bureau of Reclamation.

3. Development of the lands of the Main Stream Unit has been inhibited by the limited dependable supply of water. It is estimated that

an additional annual water supply of approximately 205,000 acre-feet would be required for use in this unit by the year 2020. New Hogan and New Melones Reservoirs would provide the water supply for most of these demands, and the supply could be augmented by pumped diversions from Folsom South Canal.

4. In the Tributary Unit, providing water can be developed within the payment capacity of the users, an additional water supply of 55,000 acre-feet per annum would be required by the year 2020. Of this amount, approximately 25,000 acre-feet could be developed locally from the Mokelumne and Calaveras River systems. The remaining 30,000 acre-feet could be diverted for consumptive use purposes from the North Fork of the Stanislaus River.

5. The proposed Calaveras Project consisting of a system of works located on the North Fork Stanislaus River and the divide between the Stanislaus and the Mokelumne and Calaveras River Basins would be a feasible means of supplying water from the Stanislaus River for use in the Tributary Unit. Benefits which would accrue to this project from generation of hydroelectric power and water-oriented recreational use are estimated to have

a present worth of \$89,161,300. The present worth of corresponding project costs would be \$81,961,700, resulting in a benefit-cost ratio of 1.12:1.

Recommendations

To aid in the implementation of a general plan of water resources development for the Calaveras area, it is recommended that:

1. The development of water resources of the North Fork of the Stanislaus River be multipurpose in nature and that provisions should be made to serve water to the Tributary Unit of the Calaveras area.

2. The Main Stream and Valley Units of the Calaveras area be considered as primary service areas of the Central Valley Project.

3. The yield of New Hogan Reservoir be made available to the Valley Unit as an interim measure, until such time as the Folsom South Canal is in operation. At that time the water demands of the Valley Unit would be satisfied by the Folsom South Canal and the full yield of the New Hogan be supplied to the Main Stream Unit.

4. In addition to taking all feasible measures, including adequate streamflow maintenance, for the preservation of the existing fish and wildlife resources, in future water development projects, provision should be made for the enhancement of such fish and wildlife resources and for the development of the recreational potential of the area to the maximum feasible extent.

5. In assigning or releasing from priority Applications Nos. 5647, 5648, 5649, 13333, 13334, 14858, and 14859, filed in furtherance of the development of water resources for the benefit of the people of California, a general reservation be made by the California Water Commission for use of such water as may be necessary for the development of the counties in which the water originates.

6. The plans for water resources development of the Mokelumne, Calaveras, and Stanislaus Rivers as presented in this bulletin serve as a general guide to the future development of the

Calaveras area, and further, that the plans be reviewed and re-evaluated at that time in the future when economic and other conditions permit the development of additional water supplies.

APPENDIX A

VIEWS AND RECOMMENDATIONS OF
STATE OF CALIFORNIA ON REVIEW REPORT FOR
FLOOD CONTROL ON NEW MELONES PROJECT
STANISLAUS RIVER, CALIFORNIA,
DEPARTMENT OF WATER RESOURCES,
APRIL 1962

APPENDIX A

INTRODUCTION

By letter dated January 4, 1962, the office of the Chief of Engineers, U.S. Department of the Army, transmitted to the Department of Water Resources, State of California, its proposed report entitled "Review Report for Flood Control on New Melones Project, Stanislaus River, California" for review and comment in accordance with the provisions of Public Law 534, 78th Congress and Public Law 85-624. Included with the report of the Chief of Engineers were reports of the Board of Engineers for Rivers and Harbors and of the District and Division Engineers. For the sake of brevity, the "Review Report for Flood Control on New Melones Project" will be referred to hereinafter as the "New Melones Report."

The New Melones Project was authorized by the Flood Control Act of 1944 at a storage capacity of 450,000 acre-feet, with provisions for possible future enlargement to 1,100,000 acre-feet. Further studies of this project by the U.S. Bureau of Reclamation including those for the contemplated East Side Division of the Central Valley Project resulted in a joint investigation by the Corps and

the Bureau of the economic justification of a project with reservoir storage capacity greater than 1,100,000 acre-feet. As a result of this joint investigation, larger storage capacity was found to be desirable. The Appropriations Committees of the Senate and House of Representatives authorized an investigation of Melones Reservoir with storage capacity greater than 1,100,000 acre-feet in October 1959. The review report on New Melones Project is a result of that joint investigation.

According to the information presented in the New Melones Report, on the basis of comparison of incremental benefits with incremental costs, New Melones Reservoir with a storage capacity of 2,400,000 acre-feet would be economically justified. This amount of storage capacity would also provide for full development of the lower Stanislaus River. A new powerplant, with an installed capacity of 150,000 kilowatts, would be included as part of the project and would provide a large portion of the project benefits.

It is stated in the New Melones Report that New Melones Reservoir with a storage capacity of 2,400,000 acre-feet, when integrated with the contemplated East Side Division of the Central Valley Project, would provide additional average annual new water supplies of about 261,000 acre-feet measured at the service area. This

service area, for the purposes of economic analysis, was assumed to be in the water deficient San Joaquin Valley.

The estimated average annual primary benefits of the New Melones Project as presented in the New Melones Report are as follows:

Flood Control	\$ 1,030,000
Irrigation	4,443,000
Power	3,993,000
Recreation (including fish and wildlife)	<u>350,000</u>
TOTAL	\$ 9,816,000

The estimated first cost of the New Melones Project is \$114,000,000 with a corresponding annual cost of \$6,223,000. The ratio of benefits to costs is 1.6 to 1.

COMMENTS OF DEPARTMENT OF WATER RESOURCES

The Department of Water Resources has a direct interest in all projects involving the development of water resources within the State. Of particular interest is the extent to which these projects are compatible with the comprehensive plan for the general and coordinated development of the water resources of California.

The California Water Plan

Optimum multipurpose development of the New Melones Reservoir site on the Stanislaus River should be

made for the purposes of flood control, water conservation, hydroelectric power production, recreation, and fish and wildlife. There is a particularly urgent need for flood control protection to lands located along the Stanislaus and lower San Joaquin Rivers.

At a public hearing on the New Melones Project conducted by the U.S. Corps of Engineers and Bureau of Reclamation in Modesto on October 17, 1960, local interests from Tuolumne, Calaveras, Stanislaus, and San Joaquin Counties generally joined in urging a delay of at least a year in further formulation of the project to allow time for completion of studies of possibilities for development of the waters of the Stanislaus River by local interests. Subsequently, the Stanislaus River Basin Group, composed of Calaveras County Water District, Tuolumne County Water District No. 2, Oakdale Irrigation District, and South San Joaquin Irrigation District, completed a report entitled "Report and Development Plan, Stanislaus River Basin Area" dated October 1961. The department has received this report and is aware of the differences in the plans to develop water at the Melones site as proposed by the Stanislaus River Basin Group with the plans as proposed by the Corps of Engineers. The principal difference is that the Stanislaus River Basin Group proposed to construct New Melones Reservoir with storage capacity of 1,100,000 acre-feet, and the Corps has proposed storage capacity of 2,400,000 acre-feet.

While it is generally desirable to have local development of water to satisfy local needs, it is also desirable to obtain optimum development of the water resources of the State. It is noted that the department has not made independent sizing studies of New Melones Reservoir integrated with the Central Valley Project. However, such studies made by the Corps and by the Bureau have been reviewed, and it appears that a multipurpose reservoir with a storage capacity of 2,400,000 acre-feet at the New Melones site would optimize development of the waters of the Stanislaus River.

The comments of the Department of Water Resources of December 9, 1960, on the draft report of the Corps has been appended to the New Melones Report. However, the portion of these comments pertaining to water rights of counties of origin have not been discussed in sufficient detail in the text of the New Melones Report to indicate concurrence by the Corps. The State has filed several applications for water rights on the Stanislaus River. The first of these were Applications Nos. 5648 and 5649, filed in 1927 specifying a service area within or adjacent to the Stanislaus River drainage basin. Under existing state water law, counties of origin cannot be deprived of any water required to supply their needs by projects operating under these applications. The proposed project would be considered substantially in conformance with The California Water Plan if it were agreed that water would be made available to the counties of origin whenever needed, as specified in water rights Applications Nos. 5648 and 5649.

Service Area

The department agrees that there is a present need in the San Joaquin Valley for all of the water that could be made available from the New Melones Project. For the purposes of the operation studies presented in the New Melones Report, future upstream depletion of the waters available to New Melones Reservoir was estimated to increase to about 60,000 acre-feet annually in the next 50 years. When the State reviewed the draft report of the New Melones Project in December 1960, the future upstream depletion of the waters of the Stanislaus River were estimated to be from about 100,000 to 120,000 acre-feet annually greater than current depletions on the basis of including service to the Hogan Service Area. This service area is located between the Calaveras and Mokelumne Rivers, east of the service area of the Folsom South Canal, and below New Hogan Dam. It has been determined from further study, that this service area could best be served by means of an exchange of water from New Hogan Reservoir and from the proposed Folsom South Canal. Therefore, it is believed that the amount of the future upstream depletion stated in the New Melones Report is reasonable.

As stated in the New Melones Report, water-deficient areas in the San Joaquin Valley to the south of the Stanislaus River could fully utilize the new yield from

the New Melones Project. However, there also is need to supply water to the Bachelor Service Area located above the service area of the Folsom South Canal between the Stanislaus and Calaveras Rivers, and below the New Melones Dam site. This area conveniently and logically could be served with water from the New Melones Project and was proposed to be provided water from the Stanislaus River under Applications Nos. 5648 and 5649. It is estimated that the annual water requirement of the Bachelor Service Area during the next 50 years will increase to about 160,000 acre-feet. It is realized that, as an alternative, this area could be served water from the proposed Folsom South Canal. But, because of the pump lifts involved, it is believed that the Bachelor Service Area should be served water from the Stanislaus River.

Irrigation Benefits

Irrigation benefits that would be realized from the proposed project were evaluated without determining the irrigation yield from the New Melones Project when integrated with the Central Valley Project. However, studies made by the Bureau and the Corps of an integrated operation were reviewed. For the purposes of the New Melones Report, operation criteria included (1) estimates of future upstream depletion of water supply of about 60,000 acre-feet, (2) minimum streamflow in the Stanislaus

River below Goodwin Diversion Dam for fishery maintenance of 100 to 200 cubic feet per second, and (3) present demands for irrigation water in the South San Joaquin and Oakdale Irrigation Districts.

To evaluate project irrigation benefits, the Bureau selected the Kaweah Delta in the San Joaquin Valley as the project service area for irrigation water because this area was considered to be reasonably typical of the area of the contemplated East Side Division by virtue of its central location and representative cropping pattern. Farm budgets used in the economic analyses included those for field crops, feeder beef, dairy, grapes, and peaches.

As described in the New Melones Report, the New Melones Project, by virtue of its integration with the Central Valley Project, could provide a new average annual yield of 261,000 acre-feet of water to presently unirrigated lands in the Kaweah Delta portion of the San Joaquin Valley. The annual irrigation benefits would be about \$8,202,000 measured at the place of water use. These benefits, including those accruing from ground water recharge and savings in pumping costs, were projected back to the reservoir by deduction of costs of the conveyance and distribution systems. The annual primary irrigation benefits creditable to New Melones Project, therefore, would be \$4,443,000 measured at the reservoir. While no specific

estimates of benefits accruing to ground water recharge or savings in pumping costs were made in reviewing the New Melones Project, it is believed that the irrigation benefits as shown in the report are reasonable. As stated in the New Melones Report, additional studies would be required to determine which of the possible alternative service areas should be served new irrigation water from the project. It is again noted, however, that the Bachelor Service Area would be a logical area to receive project water from the Stanislaus River.

Power Benefits

The New Melones Report states that due to the increasing demand for power in Northern California, power output from the New Melones Project could be readily absorbed into the power market area. In general, it is agreed that this conclusion is correct. However, it may not be practical by the year 1969 for the Northern California system to absorb power at the capacity factor assumed in the New Melones Report. The physical limitations and contract requirements pertaining to certain powerplants, limit the flexibility with respect to capacity factors, for proposed hydroelectric powerplants in Northern California.

If proposed hydroelectric generating capacity as presently contemplated by the various private, local,

state, and federal agencies is constructed, there are indications that some of this new hydroelectric capacity may not be fully useful in meeting the area load during early spring months. The Bureau of Reclamation has stated that a rather flexible mode of water releases and project operation would be permissible for the New Melones Project, when operated in connection with the irrigation purpose of the contemplated East Side Division. In that case, a minimum power generation schedule for New Melones should probably be adopted which would permit optimum integration of the existing and proposed generating facilities.

The New Melones Report states that the optimum size of the project powerplant would be selected after more detailed studies conducted in cooperation with the Federal Power Commission and other interested agencies. These additional studies are desirable, and the project powerplant capacity should be selected after review and agreement of all interested agencies concerning the dry-period operation study and the minimum generation schedule.

The Corps assumed that the operation of the New Melones Powerplant would be integrated with the operation of other powerplants of the Central Valley Project. Power operation criteria was based on an extension of agreements between the Pacific Gas and Electric Company and the U.S. Bureau of Reclamation, similar to the present contracts.

Under these assumptions, a dependable capacity of 119,000 kilowatts as stated in the report, is reasonable. However, a review of the present contracts does not appear to justify the criteria used in preparing the dry-period power operation study. There is no evidence available that the Pacific Gas and Electric Company has accepted this criteria for all future additions to the Central Valley Project. The criteria used for the power operation study of the New Melones Report, therefore, may not be realistic.

Flood Control Benefits

From a review of the flood control data and benefits presented in the New Melones Report and discussions with the Sacramento Division, Corps of Engineers, the estimated average annual flood control benefits of \$1,030,000 appear to be reasonable. This value is based on providing protection to an area of 270,000 acres, with a mean annual benefit value of \$3.81 per acre.

Recreational Benefits

Estimates of recreational benefits presented in the New Melones Report are based on an estimated number of visitor-days of use and an estimated value of a visitor-day of use.

It is believed that New Melones Reservoir would afford substantial recreation potential regardless of the anticipated fluctuations of the water leve of the reservoir. The New Melones Report shows projected total annual recreational use in the New Melones area, including fishing use, of 400,000 visitor-days initially, increasing to 800,000 visitor-days ultimately. Preliminary studies conducted for the review of the New Melones Report indicate that initial and ultimate recreation use in the order of 1,200,000 visitor-days and 2,400,000 visitor-days respectively, are more realistic estimates.

The New Melones Report notes that the National Park Service has estimated recreational benefits at \$1.60 per visitor-day, and that the U.S. Fish and Wildlife Service has suggested the use of \$5.80 per angler-day. However, as presented in the New Melones Report, in the interest of conservatism, recreational benefits have been estimated at \$0.50 per visitor-day. Studies by the Department of Water Resources in somewhat similar areas have indicated that a value of from \$1.00 to \$2.00 per visitor-day is warranted.

The New Melones Report shows a need for an acquisition of approximately 1,500 acres of land for initial public recreational development and for access and protection zones. The cost of such land acquisition would be borne by the

federal government. The National Park Service, in their study for the purposes of the New Melones Report, stated that about 1,500 acres of land for initial recreational development and an additional area of approximately 2,675 acres to accommodate the recreation needs for the balance of the repayment period would be required. They further stated that the latter land acquisition should be the responsibility of the agency administering the project recreational area. However, President Kennedy, in his 1961 message on natural resources, stated that steps should be taken to " ... insure that land acquired for the construction of federally financed reservoirs is sufficient to permit future development for recreational purposes." This policy has been adopted by the Departments of the Army and the Interior. It is believed, therefore, that the additional 2,675 acres of land necessary for future recreational development should be acquired concurrently with acquisition of all other project lands.

Insufficient detail was presented in the New Melones Report to evaluate the adequacy of public use facilities for recreational development. It was stated that it would be desirable for local interests to operate and maintain the recreational developments. This decision should receive serious consideration and coordination with the proper agencies as project plans are developed.

General Design and Project Costs

The design and estimates of cost of the New Melones Project presented in the New Melones Report were reviewed and a cursory field inspection was made of the project site. Additional design and hydrologic information was obtained from the Corps, the Bureau, and the U.S. Weather Bureau.

It is concluded that the foundation of New Melones Damsite is suitable for a rockfill embankment with a height of over 600 feet and that the embankment slopes shown in the New Melones Report are adequate. Moreover, the proposed diversion and outlet structures also are believed to be adequate. However, geologic studies indicate that the foundation rock in the area of the proposed spillway cut is not competent for an unlined spillway or for cut slopes of $1/4$ to 1. There are several zones of weak rock which intersect the chute alignment. Even under the moderate flows resulting from use of the spillway for flood control releases, these zones would be expected to erode severely. During times of large releases, these areas of weak rock would be susceptible to washouts. In view of the foregoing, it is believed that consideration should be given to modifying the spillway design.

The estimates of total project cost presented in the New Melones Report appear to be reasonable.

Upper Basin Features of the New Melones Project

There are several possible water conservation facilities in the upper basin which would optimize the development of the Stanislaus River and would develop water for local upstream use in Tuolumne and Calaveras Counties. These projects would be desirable additions to the New Melones Project. The Bureau of Reclamation currently is studying possibilities for providing water to the Sonora and Keystone Service Areas in Tuolumne County. Past studies of these service areas have indicated that an enlargement of the existing Phoenix Reservoir on Sullivan Creek, and increased diversions of water from the South Fork Stanislaus River to this reservoir, offers the best solution to satisfying present and immediate future water needs of the Sonora and Keystone Service Areas. A firm annual yield of water in the amount of about 30,000 acre-feet could be realized by enlarging Phoenix Reservoir from its existing storage capacity of 850 acre-feet to a storage capacity of 25,000 acre-feet.

Recent studies by the department indicate that there are several possibilities for supplying the water needs of Calaveras County. Local water supplies could be developed for the West Point area by providing small storage reservoirs on Forest Creek, Hunter Creek, and the Middle Fork of the Mokelumne River. New storage on the South

Fork Mokelumne River, North Fork Calaveras River, and Jesus Maria Creek operated in conjunction with water diverted from North Fork Stanislaus River would satisfy the needs of the San Andreas and Mokelumne Hill areas.

These local sources of water from tributaries of the Mokelumne and Calaveras Rivers, would not be adequate to supply present and immediate future water needs of upper Calaveras County. The only logical supplemental source of water which could be utilized to supply this area is the North Fork of the Stanislaus River. Provisions could be made to convey a firm annual yield in the amount of about 30,000 acre-feet from the North Fork of the Stanislaus River into the Calaveras River Basin for consumptive use purposes. This amount of water plus additional supplies for hydroelectric power production could be diverted through a proposed system of storage and conveyance works consisting of Spicer Meadows Reservoir on Highlands Creek and a conveyance conduit extending down the ridgetop located between Stanislaus and Calaveras River Basins. Hydroelectric power would be developed enroute at three sites near White Pines, Avery, and Stanislaus.

COMMENTS OF RECLAMATION BOARD

Mr. Robert W. James, General Manager and Chief Counsel of The Reclamation Board, by letter dated March 13, 1962, submitted the following comments.

"The flood control aspects of this project are urgently needed to increase the degree of flood control protection for the portion of the San Joaquin River Project levees along the Stanislaus River and the downstream reaches of the San Joaquin River. We feel that completion of this unit of the over-all San Joaquin River Flood Control System will add an important link to the project. We therefore urge that construction be initiated as soon as possible in order to add substantially to the flood control protection for the downstream levee system.

"The comments of the Board of Engineers for Rivers and Harbors provide that local interests shall agree to maintain the existing levees of the Stanislaus River Channel from Goodwin Dam to the San Joaquin River so as to preserve a safe carrying capacity for that reach of at least 8,000 cubic feet per second. It is also noted that the flood control operation of the project is to be accomplished in accordance with the rules and regulations prescribed by the Secretary of the Army.

"It is our understanding that no actual surveys were made of the existing levees and channels downstream from Goodwin Dam. The estimation that the existing levees and channel would be adequate for a flow of 8,000 cubic feet per second was based on observation only. In view of the open-ended obligation that this requirement could place on local interests, it is recommended that when the project design is started actual surveys be taken of the channel and levees involved and hydraulic computations be made to determine whether or not the levees are adequate both as to cross section and freeboard. If they are not, it is recommended that additional work be included in the Corps' construction contract to clear the channel and to bring the levees up to grade and section, to adequately contain a flow of 8,000 cubic feet per second.

"It is also requested that the levees be widened if necessary and that a patrol road be constructed thereon by the Corps of Engineers so that adequate maintenance can be

performed. This would involve the acquisition of necessary rights of way for this purpose. If this procedure is not followed, it would not be possible for any public district to give assurances that the levees will be maintained in accordance with the requirements of the Secretary of the Army since adequate maintenance could not be performed without a patrol road. It also would not be possible to guarantee that any public district would have access to these levees without acquisition of whatever rights of way will be required for the purpose. At the present time, these levees are in private ownership and the owners thereof could deny access to the levees if they should so desire."

COMMENTS OF DEPARTMENT OF FISH AND GAME

Mr. Harry Anderson, Deputy Director of the Department of Fish and Game, by interdepartmental communication dated March 12, 1962, submitted the following comments.

"Since the preliminary report was submitted for review we have had the opportunity to give greater consideration to all aspects of this project. The recommendations which follow parallel our previous recommendations but enlarge on them and provide greater detail. These comments and recommendations supersede all previous recommendations and constitute the official comments of this Department pursuant to P.L. 85-624, the Wildlife Coordination Act, and the general policy of the State regarding the protection and enhancement of fish and wildlife.

"Our review indicates that the Corps has not separated general recreational benefits from fish and wildlife benefits and the benefits assigned appear to be low. We believe the fish, wildlife and recreational benefits should be re-evaluated and raised.

"On page 29, the report states 'Hunting, trapping, and related use of the general area has not been evaluated; however, any change in use due to the project is believed to be small and would not affect the overall recreation accomplishments of the project.' We are not certain of the origin of this statement, but our investigation of the project reveals that a substantial amount of wildlife habitat will be inundated, or lost through changed land use patterns. These losses should be mitigated and recommendations are included for this purpose.

"The Department investigated this project jointly with personnel of the Office of River Basin Studies, Fish and Wildlife Service, and in general concurs with their evaluation regarding benefits to improve anadromous and warm water fisheries. Our recommendations parallel those of the Fish and Wildlife Service.

"Recommendations

"1. In line with recent policy of the Department of Interior and the Wildlife Coordination Act, conservation and development of fish and wildlife resources should be included and authorized as project purposes.

"2. That the Corps and the Bureau respectively provide the storage for and obtain the necessary water rights to, the quantities of water hereafter prescribed for the maintenance and enhancement of fishlife in the Stanislaus River; from Goodwin Diversion Dam, or if constructed, the proposed Knights Ferry Diversion Dam, to the confluence of the San Joaquin River; and that said water be released in accordance with the following schedule:

<u>Period</u>	<u>Flow in Cubic Feet per Second</u>	
	<u>Normal Year</u>	<u>: Dry Year^{1/}</u>
October 1 - December 31	200	150
January 1 - May 31	125	100
June 1 - September 30	100	50

^{1/} "A Dry year is defined as one in which the natural inflow into Shasta, Trinity, Folsom, and Friant Reservoirs, as predicted for the water year, totals less than 5,000,000 acre-feet, or one in which the combined water storage in Shasta, Trinity, Whiskeytown, Folsom, Auburn, and New Melones Reservoir, as predicted for the water year, is less than 5,000,000 acre-feet."

"Provided: that if the average streamflow maintained in the Stanislaus River from October 1 to December 31 is greater than the minimum flow specified for this period (exclusive of flood spill and emergency releases) the streamflow from January 1 to May 31 be maintained at not less than the specified January 1 to May 31 minimum flow, or the average of the October 1 to December 31 flow minus 100 c.f.s. whichever is greater. Provided further: that fluctuations of the Stanislaus River downstream from Goodwin Diversion Dam be limited to a rate of change not exceeding 2 inches per hour or 8 inches in any 24-hour period.

"Provided further: that during the period of October 1 to December 31 the water surface elevation not be reduced by more than 4 inches from elevations reached during flows in excess of those recommended (exclusive of flood spills and emergency releases). Water surface elevations shall be measured at Orange Blossom Bridge.

"Provided further: that flow releases into the channel of the Stanislaus River downstream from the Goodwin Diversion Dam be derived from New Melones Reservoir outlets at or near elevation 560 feet m.s.l.

"Provided further: that modifications of the above streamflow schedule, within the limits of the total quantities of water involved, be permitted upon request of the California Department of Fish and Game and the Bureau of Sport Fisheries and Wildlife if found desirable for optimum fishery production and permissible without infringing upon prior project commitments.

"Provided further: that upon request of the California Department of Fish and Game and the Bureau of Sport Fisheries and Wildlife, flows be released into the channel of the Stanislaus River in sufficient quantity to flush from salmon and trout spawning areas any silt, fines, and other debris that may have been deposited as a result of project operation. If mechanical means are used in place of, or in addition to, flushing flows, the associated costs shall be a project cost.

"3. That a minimum pool of 300,000 acre-feet of water be reserved in the reservoir for development of a reservoir fishery, wildlife conservation and general recreation purposes. Rapid and extreme fluctuations are to be avoided insofar as is consistent with project purposes, particularly during the fish spawning season, April through June.

"4. Reservoir clearing plans be developed in cooperation with the Department of Fish and Game and U.S. Bureau of Sport Fisheries and Wildlife.

"We believe about 2,500 to 3,000 acres of trees and brush could be retained in the reservoir area without affecting adversely other uses, and which will be highly beneficial to fish and small game. If left intact this could result in a savings of clearance costs on the order of \$425,000 to \$525,000 (\$175.00 per acre) which could be applied to land acquisition for wildlife mitigation, and public access and recreation.

"5. Acquisition by fee-title or easement of approximately 3,400 acres of privately owned riparian land along the Stanislaus River downstream from Knights Ferry Bridge. Under a general plan this riparian land would be devoted to management for fish and wildlife purposes to mitigate wildlife damages resulting from the project and to assure retention of riparian habitat and preservation of the spawning gravels of the river.

"6. Withdrawal of 2,670 acres of Bureau of Land Management land adjacent to the east side of New Melones Reservoir. Land withdrawn under this paragraph would serve to mitigate wildlife habitat losses due to inundation. It is proposed that these lands can be managed as multiple purpose recreation lands including wildlife management under plans developed jointly by the Bureau of Land Management, Bureau of Sport Fisheries and Wildlife, and the California Department of Fish and Game. These lands would be managed by the State Department of Fish and Game.

"7. Stringent controls be imposed on construction activities to prevent the destruction of fish and wildlife habitat in and adjacent to Stanislaus River.

"8. The existing Melones Dam be breached so as to permit the free flow of subsurface water within New Melones Reservoir. The Department and the Bureau of Sport Fisheries and Wildlife should be consulted on this matter prior to breaching the dam.

"9. A zoning plan should be established for the new reservoir to insure that specified areas of the reservoir will be available for fishing and hunting, and other fish and wildlife purposes without conflicting with other proposed recreational uses. The Department will be happy to cooperate with other interested agencies in the development of such a plan for recommendation to the appropriate regulatory agencies.

"10. Such reasonable modifications be made in the project operation and facilities as may be agreed upon by the Corps of the Engineers, the U.S. Fish and Wildlife Service, and the Department of Fish and Game for the conservation and development of fish and wildlife resources.

"11. Federal land and project waters, except such portions as may be reserved for public safety, protection of property and efficient operation, be open to the public without fee for the purposes of hunting and fishing.

"12. Leases of Federal land in the project area reserve the right of public access without fee for the purposes of hunting and fishing.

"13. In accordance with the recently announced Federal policy regarding land acquisition at Federal project for future development in the public interest; and to provide incidental and additional mitigation acquire an additional 4,560 acres of private land located on the eastern side of New Melones

Reservoir. These lands would be managed for wildlife in accordance with a plan developed jointly by the Bureau of Sport Fisheries and Wildlife, Bureau of Land Management and the Department of Fish and Game.

"14. Opportunity be provided to select and manage for fish and wildlife purposes other isolated parcels of land and lands contiguous to the reservoir acquired for project purposes.

"15. Project funds in the amount of \$25,000 be provided for development of lands under paragraphs 6, 13, and 14 for wildlife mitigation purposes.

"In making these recommendations the Department has taken cognizance of the President's recent declaration and the most recent policies of the Departments of Interior and Army regarding Reservoir Project Lands. These policies are set forth by Secretary of the Interior in the Departmental Manual, Part 751 'Reservoir Projects Lands.'

"Specific reference is made to Section 751.1.1 of Chapter 1, Policies, and Section 751.1.4 Land Acquisition. Among other things this policy states, 'The fee title will be acquired to the following': 'Such lands as are needed to meet present and future requirements for fish and wildlife as determined pursuant to the Fish and Wildlife Coordination Act.'

"The joint policy statement of the Departments of Interior and Army is identical in wording to the above. These policies were approved by the Secretaries of Interior and Army on February 16, 1962. . . .

"Inclusion of all of the above recommendations will adequately protect and appreciably enhance fish and wildlife and recreation in the project area.

"We appreciate the opportunity to review this report. The New Melones project affords and excellent opportunity for water development with protection and improvement of the State's fish and wildlife resources."

COMMENTS OF DIVISION OF HIGHWAYS

Mr. J. C. Womack, State Highway Engineer, by interdepartmental communication dated February 19, 1962, stated that he previously commented on the draft of the New Melones Review Report and that the comments made then are still valid. Additional comments were submitted as follows:

The New Melones " ... Review Report indicates on Plates I and III a proposed relocation for legislative State Highway Route 65. The Division does not necessarily concur in the location indicated and advises alternate routes must be given study before a recommendation can be made to the California Highway Commission regarding adoption of a route to supersede the portion of highway inundated. From one to two years will be required for the reconnaissance and public hearing phases of this study in the two counties concerned before the design stage can be initiated."

COMMENTS OF DEPARTMENT OF CONSERVATION

Mr. W. D. Winters, Deputy State Forester, by interdepartmental communication dated March 6, 1962, submitted the following comments.

"It should be noted that the stream bed in the North Fork of the Stanislaus River and its principal tributaries, Rattlesnake Creek, Beaver Creek, Griswald Creek and Skull Creek, contain large deposits of debris, within the creek beds and adjacent slopes, that can be carried down stream during peaks of high water. There is a large program of work to be done in stream clearance that should be carried on prior to, or during, construction of the project, to eliminate some of the potential hazards to the catch basin of the reservoir.

"There are no Division of Forestry structures, power or telephone lines involved in the proposed reservoir below the contemplated high water level and no new stations or other facilities are contemplated at the present time or within the foreseeable future, in either ranger unit. This situation can change, however, depending upon recreational developments that may be installed and the use that such facilities may receive.

"The Division of Forestry maintains the following roads and fire breaks within the area, for fire protection purposes. These facilities are all above contemplated high water level, except as noted under fire breaks:

"Roads - Fowler Peak 4.5 mi.; Ponderosa Way 7.2 mi.; Raggio Mill 3.0 mk.; Hunter Pt. 4.0 mi.; Dorrington - Sour Grass 25.0 mi; McCormick Meadows 12 mi; Sour Grass 6.0 mi; Griswald Creek 9.5 mi; Lower Beaver 4.5 mi; Ramsey 4.0 mi; McCormick Lookout 2.0 mi; Burnt Corral 8.0 mi. Total road miles 89.7.

"Firebreaks - Darby Knob 4.5; Skunk Gulch 3.0 mi; Mariane Gulch 2.0 mi; Otter Bar 0.5 mi. Total Firebreak miles 10.

"The lower portions of the last three firebreaks will be below the contemplated high-water level. However, this will in no way affect their usefulness for the purpose they were intended for. Shortened mileage will be the only effect.

"No comment can be made, at this time, on other public and private roads, pending study of final plans and maps of the reservoir itself and proposed relocation of existing roads."

CONCLUSIONS

As a result of review of the New Melones Report by the various state agencies concerned, it is concluded that:

1. Optimum multipurpose development of the New Melones Reservoir site should be made for the purposes of flood control, water conservation, hydroelectric power, recreation, and fish and wildlife. Reservoir storage capacity of 2,400,000 acre-feet as planned in the report, is adequate for these purposes.

2. To be in conformance with objectives of The California Water Plan the New Melones Project should be subject to the rights of the upstream areas dependent upon waters of the Stanislaus River to use water required for the future development of such areas.

3. On the assumption that the Hogan Service Area will be served by an exchange of water from the Folsom South Canal and from New Hogan Reservoir, estimates of future upstream depletions as presented in the New Melones Report are reasonable.

4. The design of the dam and appurtenances are adequate and estimated project costs are reasonable.

5. The flood control aspects of the project are urgently needed.

6. The New Melones Project appears to be economically justified.

7. If adequate provisions are made for land acquisition and releases of water for stream flow maintenance, the New Melones Project will protect and enhance fish, wildlife, and recreation.

8. It has not fully been demonstrated that the channel downstream from Goodwin Diversion Dam is adequate to contain a flow of 8,000 cubic feet per second.

9. The New Melones Project does not adequately provide for the water needs of Calaveras and Tuolumne Counties and the Bachelor Service Area.

RECOMMENDATIONS

It is recommended that the proposed New Melones Project on the Stanislaus River be authorized by the Congress at an early date for construction and operation by the federal government; provided that:

1. Recognition be given to the right of the upstream areas dependent upon waters of the Stanislaus River to develop and utilize water required for the future development of such areas.

2. Water be released downstream for fisheries purposes and land be acquired for recreation and wildlife as previously recommended herein.

3. Studies be authorized to develop the full potential of the North Fork of Stanislaus River, including formulation of additional features of the New Melones Project designed to serve 30,000 acre-feet of water each year initially increasing to 50,000 acre-feet by the year 2015, for use in upper Calaveras County. Further, that the Sonora-Keystone Investigation of the Bureau of Reclamation be programmed to formulate features of the New Melones Project to provide 30,000 acre-feet each year to the Sonora-Keystone area.

4. The Bachelor Service Area be served water from the New Melones Project or by an exchange from the Folsom South Canal.

APPENDIX B

LETTER, DATED FEBRUARY 25, 1958,
DEPARTMENT OF WATER RESOURCES TO
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO,
REGARDING REVIEW BY THE DEPARTMENT
OF THE CORPS OF ENGINEERS, DRAFT,
"REPORT ON PRELIMINARY COST ALLOCATION STUDIES,
NEW HOGAN PROJECT, CALAVERAS RIVER, CALIFORNIA."

APPENDIX B

February 25, 1958

Colonel A. E. McCollam
U.S. Army Engineer District, Sacramento
Corps of Engineers
P.O. Box 1739
Sacramento 8, California

Dear Colonel McCollam:

This is in reply to your letter of January 20, 1958, transmitting copies of your draft of "Report on Preliminary Cost Allocation Studies, New Hogan Project, Calaveras River, California", dated December 23, 1957, and requesting comments of this Department. The report has been reviewed and our informal comments are submitted herein.

The report presents a cost allocation study of the authorized New Hogan Project on Calaveras River. It is noted that the study is based on the following general criteria:

1. Gross storage of 325,000 acre-feet in New Hogan Reservoir.
2. Operation of the reservoir for flood control and irrigation, but primarily for flood control.
3. Probable net depletion of 5,600 acre-feet annually in the inflow to the reservoir due to future development and use of water upstream.
4. New irrigation yields assumed, for cost allocation purposes, to be used in lands within the Stockton and East San Joaquin Water Conservation District.

The report states that the project would produce an average annual yield of new water of approximately

40,000 acre-feet. Capital and annual costs of the project are estimated to be \$17,000,000 and \$734,000 respectively. Annual benefits are computed to be \$1,050,000 for flood control and \$314,000 for irrigation. Based on the separable costs--remaining benefits method the report allocates 62.1% of the capital cost to flood control and 37.9% to irrigation. The benefit-cost ratio is computed to be 1.86 to 1.

The Department of Water Resources believes that the estimates of capital and annual costs set forth in the "Allocation Report" are reasonable, and that the new water yield of the project has been derived with consideration of probable future depletion in the flow of Calaveras River at the New Hogan Dam site. Assuming that the irrigation yields of the project would be used in the Stockton and East San Joaquin Water Conservation District, the Department agrees with the cost allocation of 62.1% for flood control and 37.9% for irrigation. The final cost allocation, of course, should be based on benefits from the areas on which project water is actually used. We also assume that the cost allocation made would not preclude the use of water for other than irrigation and flood control purposes in the event such need arises.

So far as water requirements are concerned, our own studies indicate that the Stockton and East San Joaquin Water Conservation District will require supplemental water supplies of about 52,000 acre-feet annually to support full development and to eliminate the overdraft on the ground water basin. This area could be served, of course, by either the proposed New Melones Project or by the proposed Folsom South Canal, as well as by the New Hogan Project.

The Department of Water Resources is concerned with the disposition and use of the waters of Calaveras River from the standpoint of The California Water Plan, as well as from the standpoint of water rights. These aspects, of course, are closely related. The California Water Plan includes a reservoir of 325,000 acre-feet as the New Hogan site and proposes that the waters conserved by the project be used ultimately in the Hogan and Bear Creek Service Areas. These service areas include lands lying generally between New Hogan Dam and the proposed Folsom South Canal. They contain approximately 58,000 acres of irrigable land, only about 1,000 acres of which are irrigated at present. The ultimate water requirement in the two service areas is estimated to be about 123,000 acre-feet annually. The Department of Water Resources

believes that all of the yields available at New Hogan Reservoir should be used eventually in the Hogan and Bear Creek Service Areas and supplemented by development of ground water and by pumped diversions from Folsom South Canal to the extent possible. The area in Calaveras County upstream from New Hogan Reservoir, in addition to whatever will be supplied to it from the Calaveras River, will eventually require all of the water possible to develop from the North Fork of the Stanislaus River. Consequently, the New Hogan Reservoir is the only logical source of a gravity supply to the Bear Creek and Hogan Service Areas.

Water rights for the operation of New Hogan Reservoir would involve the partial assignment of State Filing No. 5648 insofar as that application involves the Calaveras River. Application 5648, filed by the Department of Finance in 1927, proposes, in part, diversions from Calaveras River at the New Hogan Reservoir in the amount of 800 cubic feet per second and 100,000 acre-feet of storage per annum. The uses to which this water is to be applied under the application are irrigation and domestic use in those areas of the San Joaquin and Calaveras Counties lying generally between New Hogan Dam and the proposed Folsom South Canal, and includes the Bear Creek and Hogan Service Areas. The place of use specified in Application No. 5648 does not include the Stockton and East San Joaquin Water Conservation District area.

During July, 1956, the Department of Water Resources was created and succeeded to and is now vested with all the powers, duties, purposes, responsibilities, and jurisdiction originally vested in the Department of Finance under Division 6, Part 2 of the Water Code. The provisions under this part authorize the Department of Water Resources to make and file applications for any water which, in its judgment, is or may be required in the development and completion of the whole or any part of a general or coordinated plan looking toward the development, utilization, or conservation of the water resources of the State. In addition, this part also provides that the Department of Water Resources may release from priority or assign any portion of any application filed by it when the release or assignment is for the purpose of development not in conflict with such general or coordinated plan. At the time of release or assignment of any State filing, adequate reservations must be made to the County of Origin under Section 10505 of the Water Code.

Requests have been received by the Department from the Calaveras County Water District and the Stockton and East San Joaquin County Water Conservation District for an

assignment or release from priority of that portion of Application 5648 which covers appropriations from the Calaveras River at the New Hogan site. These requests will probably in the near future be referred to the California Water Commission for consideration and recommendation. Subsequent thereto, a joint hearing will be conducted by the Commission and the Department, and all interested parties will be invited to present their views as to what disposition of these requests should be made and what terms and conditions should be included in any disposition of Application 5648.

In addition to the disposition of Application 5648 by the Department of Water Resources, it will be necessary for the State Water Rights Board to conduct a hearing on all pending applications proposing appropriations from the Calaveras River stream system. The pertinent features of those applications which propose diversions from the Calaveras River at the New Hogan site are set forth in the following tabulation.

Application :	Applicant	Amounts		Diversions		Purpose of use
		CFS :	APA :	season :		
11792	Calaveras County Water District	50	100,000	1/1-12/31 10/1-7/1		Domestic, irrigation, industrial municipal, mining, recreational
12668	Stockton & East San Joaquin Water Conservation District		76,000	2/15-7/1		Domestic, irrigation
17695	City of Stockton		100,000	11/1-6/15		Municipal

In view of the pending requests before the Department of Water Resources for disposition of Application 5648 and the pending water right applications on file with the State Water Rights Board proposing appropriations from the Calaveras River system, considerable time will be required before final disposition can be made of this complex water rights problem.

Construction of New Hogan Reservoir to a capacity of 325,000 acre-feet would provide the flood protection needed now in the Stockton area and would also provide the full development of Calaveras River for conservation purposes. When the Folsom South Canal is constructed, all of

the physical facilities needed to provide direct service to the Stockton and East San Joaquin Water Conservation District, as well as to the Bear Creek and Hogan Service Areas, will exist. Consequently, the Department of Water Resources supports early construction of New Hogan Reservoir, as proposed by the Corps of Engineers. The Department feels, also, that the water conserved by New Hogan Reservoir may be used in the Stockton and East San Joaquin Water Conservation District on an interim basis, but that it will have to be transferred eventually to use in the Hogan and Bear Creek Service Areas.

APPENDIX C

RELATED INVESTIGATIONS AND REPORTS

APPENDIX C

RELATED INVESTIGATIONS AND REPORTS

Several prior investigations and reports were reviewed in connection with this investigation and are described briefly below.

Statewide Water Resources Investigation

The Statewide Water Resources Investigation by the Division of Water Resources was conducted under the direction of the State Water Resources Board and the Department of Water Resources and the results were published in three bulletins. Bulletin No. 1, "Water Resources of California," published in 1951, contains a compilation of data concerning precipitation, unimpaired streamflow, flood flows and frequencies, and quality of waters throughout the State. Bulletin No. 2, "Water Utilization and Requirements of California," published in 1955, sets forth estimates of present and probable ultimate water requirements throughout the State based, in general, on the capabilities of the land to support further development. The third and concluding phase of the Statewide Water Resources Investigation was reported in Bulletin No. 3, "The California Water Plan," published in 1957. This plan is a comprehensive master plan for the full development of the water resources of the State

to meet present and future needs for all beneficial purposes in all parts of the State, insofar as is practical.

Survey of Mountainous Areas

The Survey of Mountainous Areas was initiated by the State Water Resources Board in 1946 to evaluate the ultimate water needs and make plans for projects to supply these needs for all or portions of 13 counties. The area of the investigation was the foothill and mountainous areas of the west slope of the Central Sierra Nevada Range, including all of Calaveras County. Results of the investigation were published in 1955, as Bulletin No. "56" of the Division of Water Resources, 1955.

San Joaquin County Investigation

The San Joaquin County Investigation was initiated by the State Water Resources Board in 1948 to inventory the water requirements and surface and ground water resources of San Joaquin County. Using the data developed in these inventories, plans were formulated for developing the available water resources for local use. A report on this investigation (Bulletin No. 11, "San Joaquin County Investigation") was issued in 1955, and Supplements I-IV have been issued between May 1956 and March 1959.

Basic Data Reports

The Department of Water Resources conducts continuing programs in which the water resources of the State are measured as to quantity and quality. Within the limitations imposed by available funds and personnel, these data are reported annually in a series of bulletins as follows:

1. The series 23 bulletins presents stream gaging data, as for example, Bulletin No. 23-61, "Surface Water Flow for 1961."

2. The series 77 bulletins present similar data for ground water, e.g., Bulletin No. 77-60, "Ground Water Conditions in Central and Northern California, 1960."

3. The series 65 bulletins refer to quality of surface waters, e.g., Bulletin No. 65-61 Part I, "Quality of Surface Waters in California, 1961, Part I, Northern and Central California."

4. The series 66 bulletins show water quality data for ground water as in Bulletin No. 66-60, Part I, "Quality of Ground Waters in California, 1961, Part I, Northern and Central California."

The number after the dash identifies the year in which the data was collected in the field.

Other Investigations and Reports

Other reports containing information and data that were reviewed and utilized for the purposes of the Calaveras Area Investigation are:

1. California State Department of Public Works, Division of Water Resources. "Water Rights Applications by State Department of Finance, Assignments Thereof, Reservations for Counties of Origin, and Other Related Matters." February 1955.

2. California State Department of Water Resources. Report No. 7, "Quality of Ground Water in the Stockton Area, San Joaquin County." March 1955.

3. California State Department of Public Works, Division of Water Resources. "Water Resources of Stanislaus River." June 1951.

4. Stanislaus River Basin Group. "Report and Development Plan, Stanislaus River Basin Area." October 1961.

5. Stone and Webster Engineer Corporation.
"Report on Water Supply for City of Stockton,
Stockton, California." October 1955.

6. The U.S. Department of the Interior,
Bureau of Reclamation. "Folsom South Unit,
Central Valley Project, California."
January 1959.

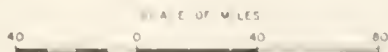
7. The U.S. War Department, Corps of
Engineers, Sacramento District. "Report
on Economic Feasibility, New Melones
Project, Stanislaus River, California."
March 1957.

8. The U.S. War Department, Corps of
Engineers, Sacramento District. "Report
on Preliminary Cost Allocation Studies,
New Hogan Project, Calaveras River,
California." December 1957.

9. Tudor Engineering Company. "Feasibility
Report and Plan, Calaveras County Water Develop-
ment." As revised, August 1961.

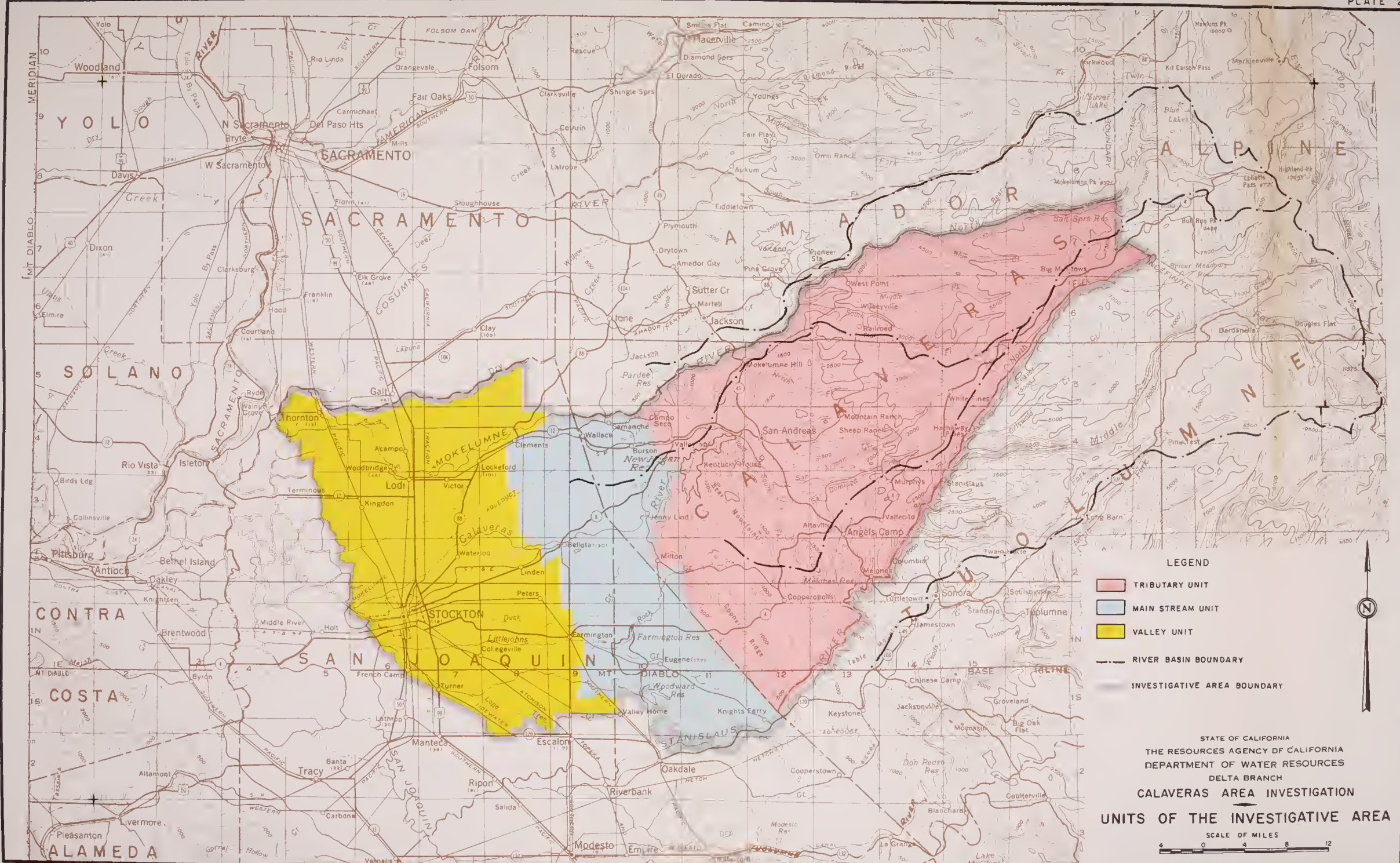


STATE OF CALIFORNIA
 THE RESOURCES AGENCY OF CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
 DELTA BRANCH
 CALAVERAS AREA INVESTIGATION
 LOCATION OF CALAVERAS AREA



SCALE OF MILES





LEGEND

- TRIBUTARY UNIT
- MAIN STREAM UNIT
- VALLEY UNIT
- RIVER BASIN BOUNDARY
- INVESTIGATIVE AREA BOUNDARY

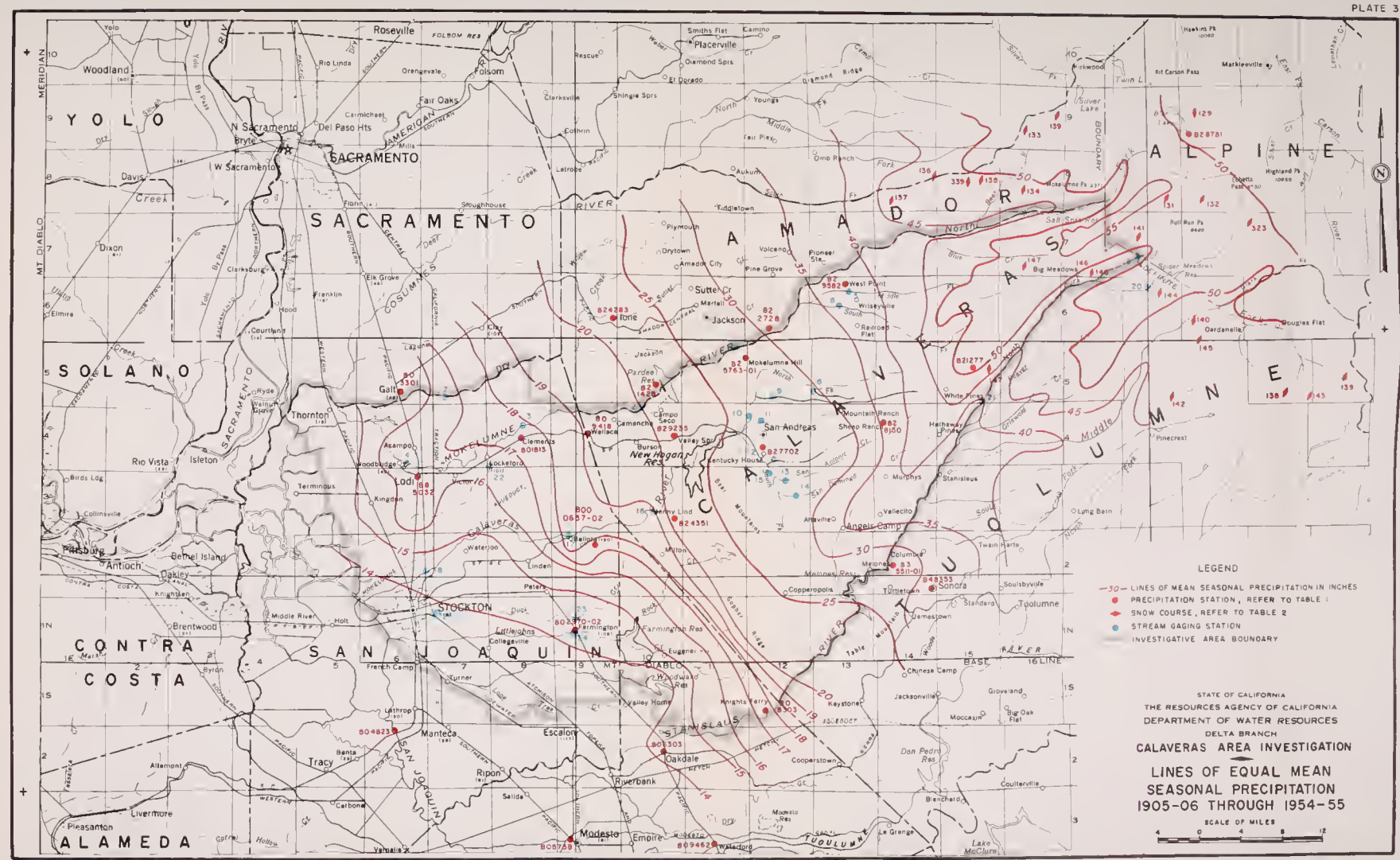
STATE OF CALIFORNIA
 THE RESOURCES AGENCY OF CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
 DELTA BRANCH
 CALAVERAS AREA INVESTIGATION
UNITS OF THE INVESTIGATIVE AREA
 SCALE OF MILES
 0 4 8 12



INDEX TO STREAM GAGING STATIONS

INDEX NO.	OWR NO.	STREAM
1	B21375	MOKELUMNE RIVER
2	B21170	MOKELUMNE RIVER
3	B02130	MOKELUMNE RIVER
4	B94300	MOKELUMNE RIVER
5	B23100	MIDDLE FORK MOKELUMNE RIVER
6	B24100	SOUTH FORK MOKELUMNE RIVER
7	B01510	DRY CREEK
8	B26300	ESPERANZA CREEK
9	B26200	JESUS MARIA CREEK
10	B26150	NORTH FORK CALAVERAS RIVER
11	B26100	MURRAY CREEK
12	B26250	CALAVERITAS CREEK
13	B27150	SAN ANTONIO CREEK
14	B27200	SAN DOMINGO CREEK
15	B27100	SOUTH FORK CALAVERAS RIVER
16	B02590	CALAVERAS RIVER
17	B02555	CALAVERAS RIVER
18	B02520	CALAVERAS RIVER
19	B22300	NORTH FORK STANISLAUS RIVER
20	B32150	HIGHLAND CREEK
21	B32100	NORTH FORK STANISLAUS RIVER
22	B02045	BEAR CREEK
23	B02850	DUCK CREEK
24	B02870	LITTLEJOHNS CREEK
25	B02835	DUCK CREEK

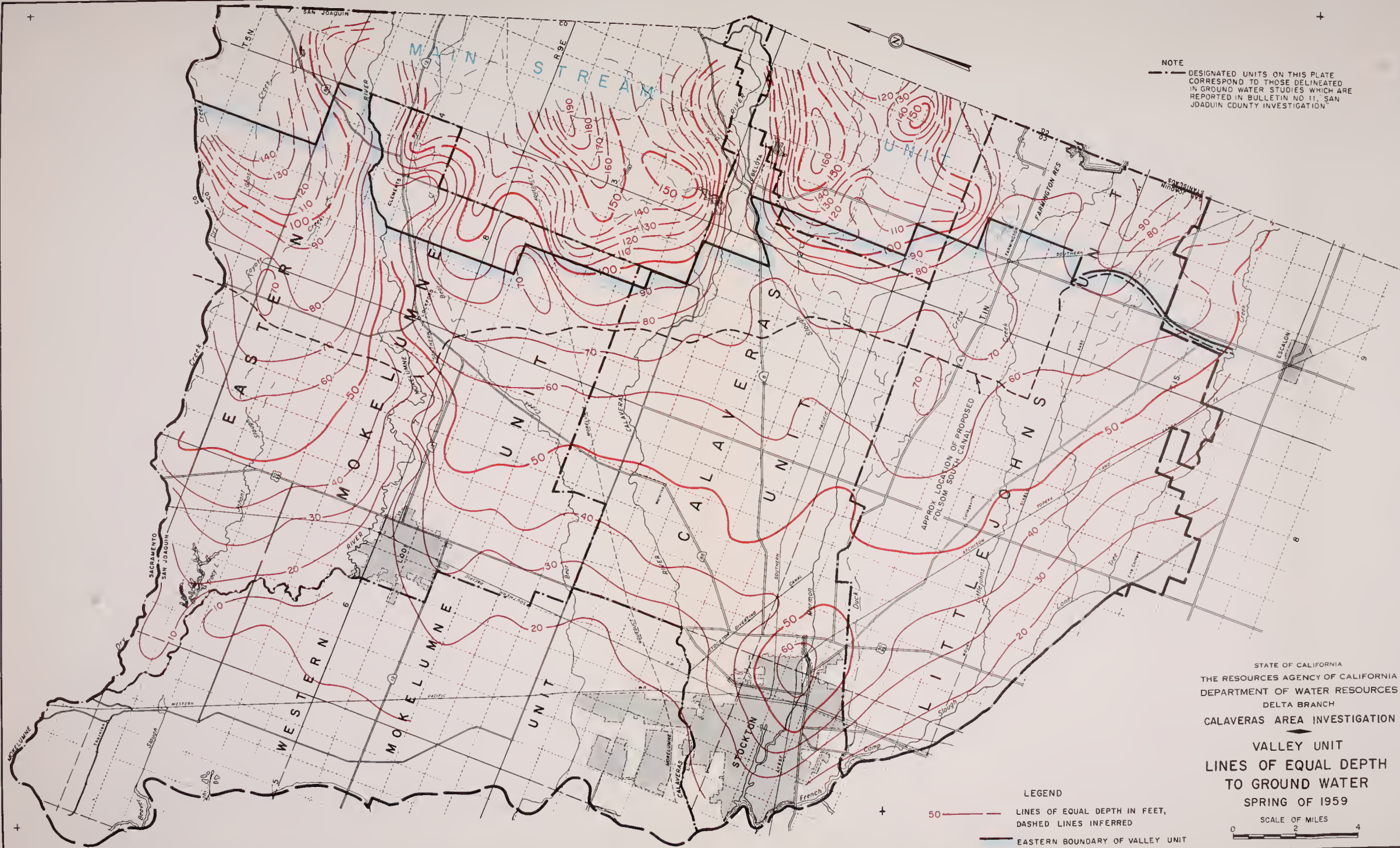
REFER TO TABLE 7 FOR FURTHER DATA.

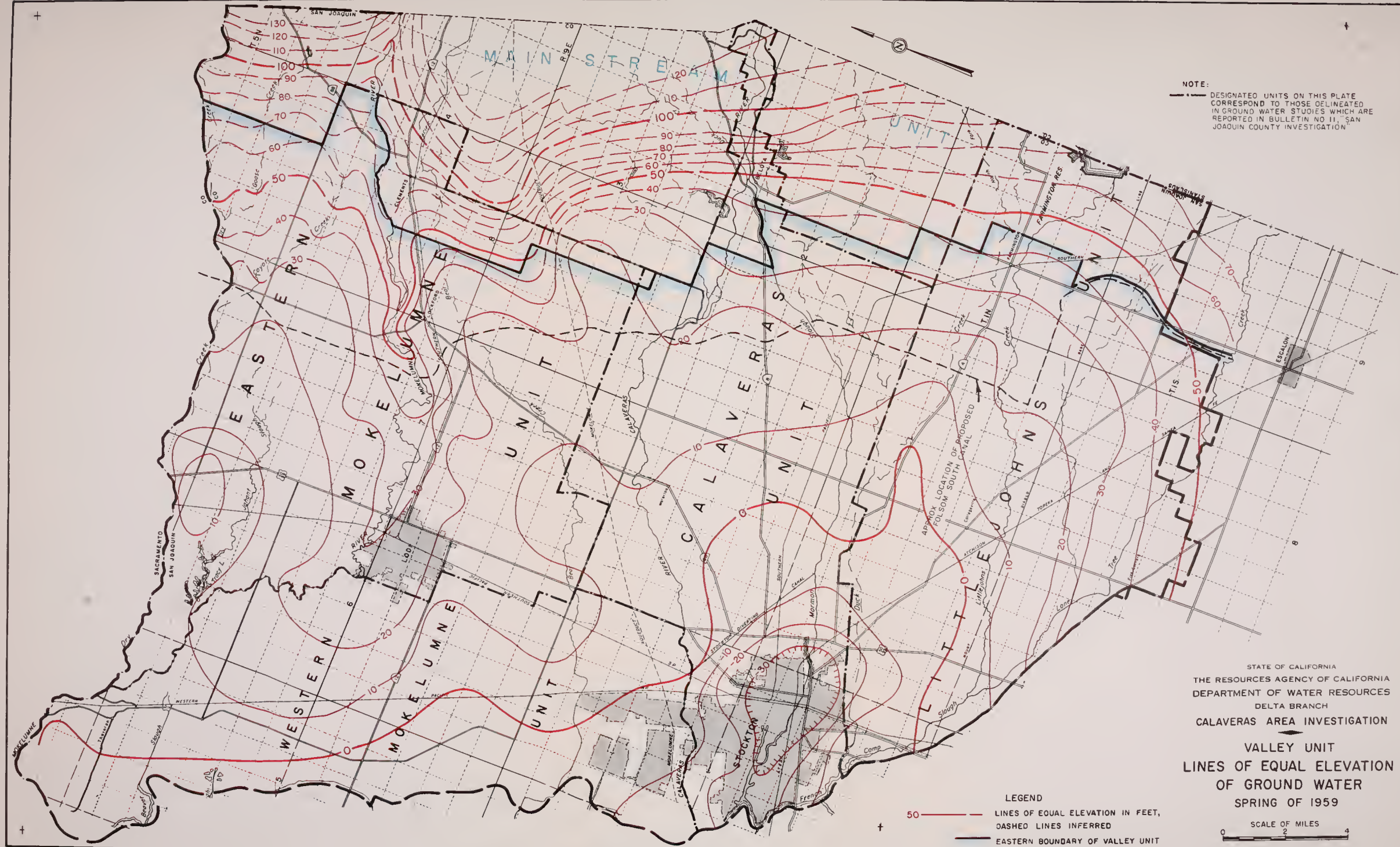


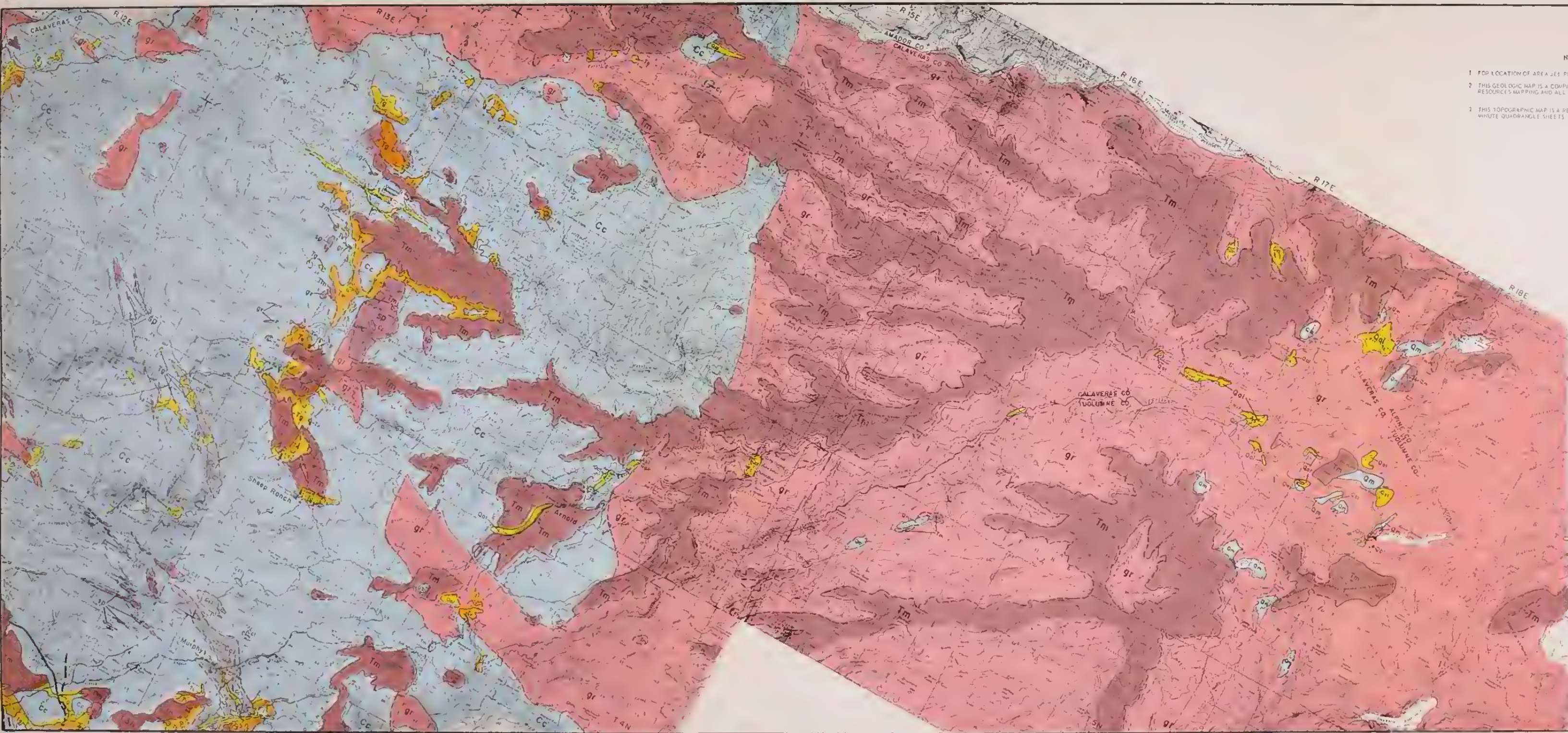
LEGEND

- 50— LINES OF MEAN SEASONAL PRECIPITATION IN INCHES
- PRECIPITATION STATION, REFER TO TABLE 1
- ◆ SNOW COURSE, REFER TO TABLE 2
- STREAM GAGING STATION
- - - INVESTIGATIVE AREA BOUNDARY

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
CALAVERAS AREA INVESTIGATION
Lines of Equal Mean Seasonal Precipitation 1905-06 THROUGH 1954-55
SCALE OF MILES
0 4 8 12







NOTES

1. FOR LOCATION OF AREA SEE PLATE 1
2. THIS GEOLOGIC MAP IS A COMPILATION OF DEPARTMENT OF WATER RESOURCES MAPPING AND ALL AVAILABLE GEOLOGIC MAPPING
3. THIS TOPOGRAPHIC MAP IS A REDUCTION OF A MOSAIC OF USGS 15 MINUTE QUADRANGLE SHEETS

STRATIGRAPHY

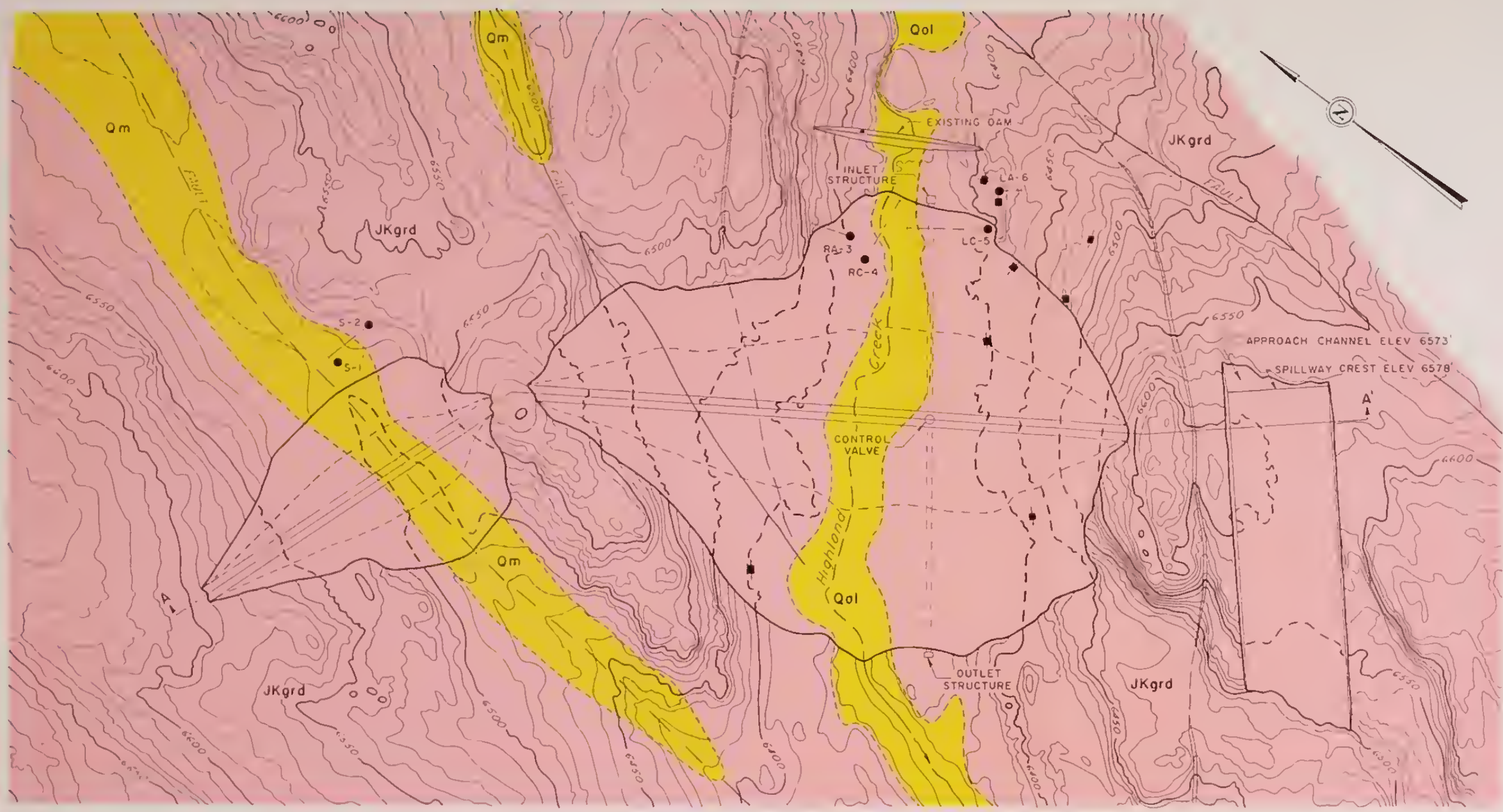
QUATERNARY	Qal	ALLUVIUM
	Qm	GLACIAL MORAINES AND FILL
		GENERALY UNCONSOLIDATED, UNSORTED GLACIAL DEPOSITS OF CLAY TO BOULDER SIZE
WIDENE AND PLEISTOCENE		UNCONFORMITY
		WEHRTEN FORMATION
		ANDREITIC FLOWS, MUDFLOWS, ASSOCIATED STREAM-LAID DEPOSITS, INCLUDES TABLE MOUNTAIN LATE VOLCANIC TUFF OF PLEISTOCENE OR PLEISTOCENE AGE
PLIOCENE		UNCONFORMITY
		VALLEY SPRINGS FORMATION
		RHODOLITE TUFF AND ASSOCIATED STREAM-LAID DEPOSITS
		UNCONFORMITY
		IONE FORMATION
		NONE IN THIS AREA
EOCENE		UNCONFORMITY
		AURIFEROUS GRAVELS
		STREAM-LAID AND PLAYS DEPOSITS OF AS-TOPOGRAPHICALLY THE SAME AGE AS IONE TYPES
UPPER JURASSIC		UNCONFORMITY
		MARIPOSA FORMATION
		NONE IN THIS AREA
UPPER OR MIDDLE JURASSIC		LOGTOWN RIDGE FORMATION
		NONE IN THIS AREA
CARBONIFEROUS		AMADOR GROUP
		Cc
		Ccl
		CALAVERAS FORMATION
		PHYLLITE, SLATE, QUARTZITE, SLATE, TECTONIC BRECCIA, INCLUDES LARGE AREAS OF GREEN SCHIST OF INDETERMINATE AGE WHICH COULD BE PART OF THIS UNIT OR POSSIBLY CORRELATIVE WITH LOGTOWN RIDGE FORMATION. PORTIONS OF METAVOLCANIC TUFF, LENS, AND SLATE OF RECENTLY DIFFERENTIATED COOLWATER FORMATION INCLUDED IN THIS UNIT.
INTRUSIVES		
UPPER OR LOWER CRETACEOUS		
		GRANITIC ROCKS
		LARGELY COARSE GRAINED GRANODIORITE, BUT INCLUDES GRANITIC ROCKS USUALLY BELIEVED TO BE ASSOCIATED WITH THE GRANODIORITE SUCH AS GABBRO AND DIORITE
		ULTRABASIC ROCKS
		LARGELY SERPENTINE, SILICA CARBONATE ROCKS AND OTHER VULCANIC (OR SERPENTINE) INCLUDES ASSOCIATED DIORITE AND GABBRO

SYMBOLS

GEOLOGIC CONTACT, DASHED WHERE INFERRED OR INDEFINITE

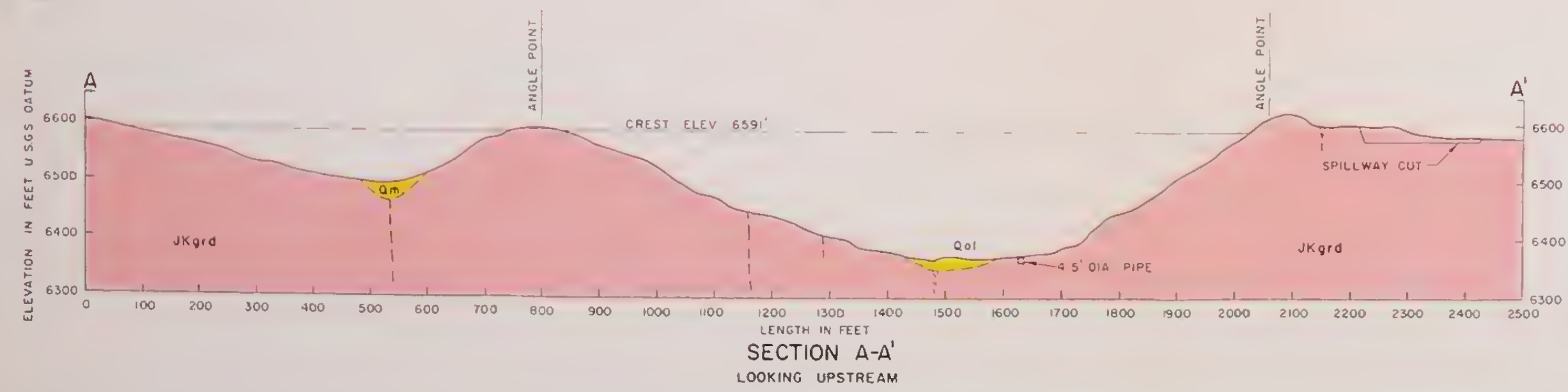
FAULT, DASHED WHERE INFERRED

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REGIONAL GEOLOGY
SCALE OF MILES
0 1 2

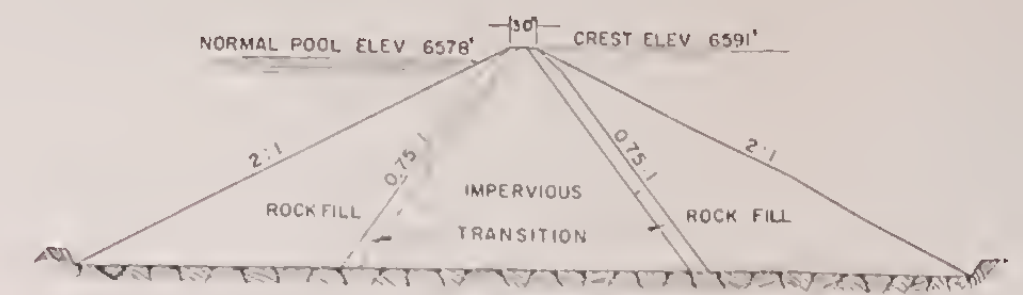


GENERAL PLAN

SCALE OF FEET
150 0 150



SECTION A-A'
LOOKING UPSTREAM

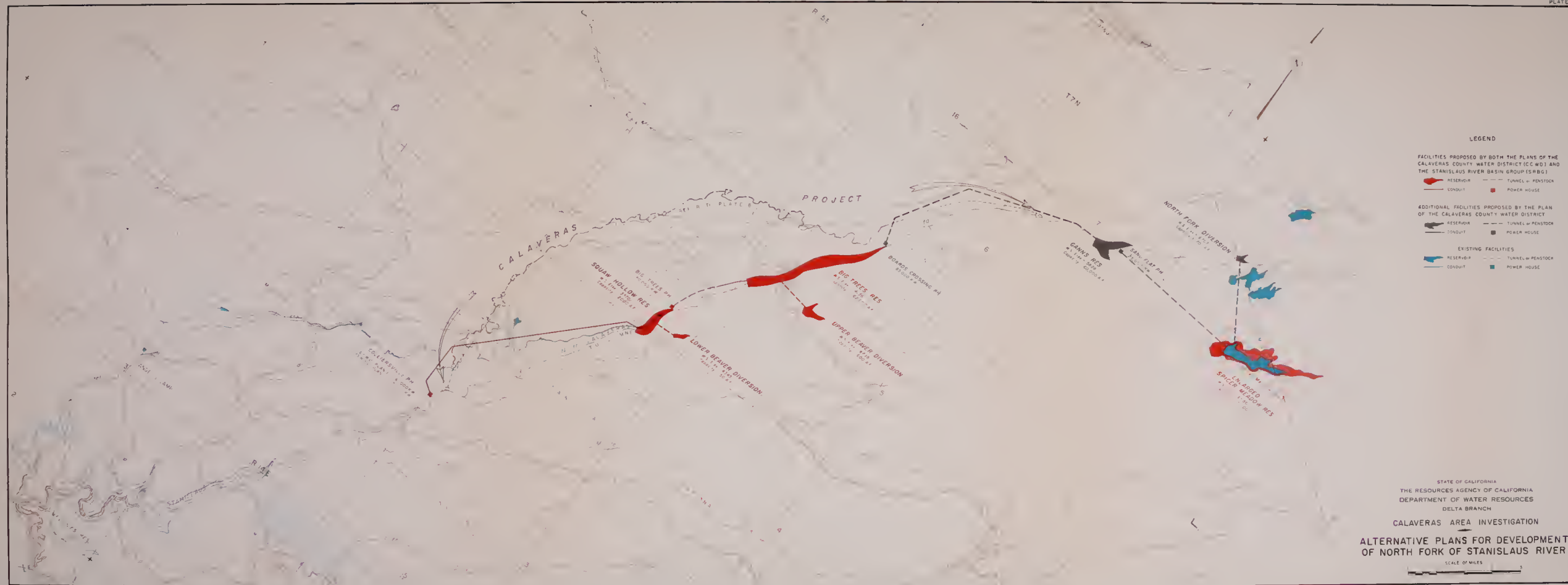


SECTION OF DAM

SCALE OF FEET
150 0 150

- LEGEND
- Qol ALLUVIUM
SILT, SAND, GRAVEL AND BOULDER DEPOSITS, POORLY SORTED AND UNCONSOLIDATED.
 - Qm GLACIAL MORaine AND OUTWASH DEPOSITS
CLAY, SILT, SAND, AND GRAVEL, POORLY SORTED AND UNCONSOLIDATED
 - JKgrd GRANITIC ROCK
COARSE-GRAINED, HARD, JOINTED GRANODIORITE TO DIORITE
- SYMBOLS
- APPROXIMATE GEOLOGIC CONTACT
 - FAULT, GENERALLY VERTICAL WITH SLIGHT HORIZONTAL MOVEMENT, DASHED WHERE INFERRRED
 - VERTICAL JOINT (EACH SYMBOL MAY REPRESENT SEVERAL JOINTS)
 - HORIZONTAL JOINT (EACH SYMBOL MAY REPRESENT SEVERAL JOINTS)
 - DECOMPOSED GRANITIC ROCK ALONG SEVERAL CLOSELY SPACED JOINTS
 - S-1 VERTICAL DRILL HOLE
 - RA-3 INCLINED DRILL HOLE
 - A-A' SECTION THROUGH AXIS OF DAM

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ON HIGHLAND CREEK



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 ALTERNATIVE PLANS FOR DEVELOPMENT
 OF NORTH FORK OF STANISLAUS RIVER
 SCALE OF MILES

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SCALE OF MILES
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